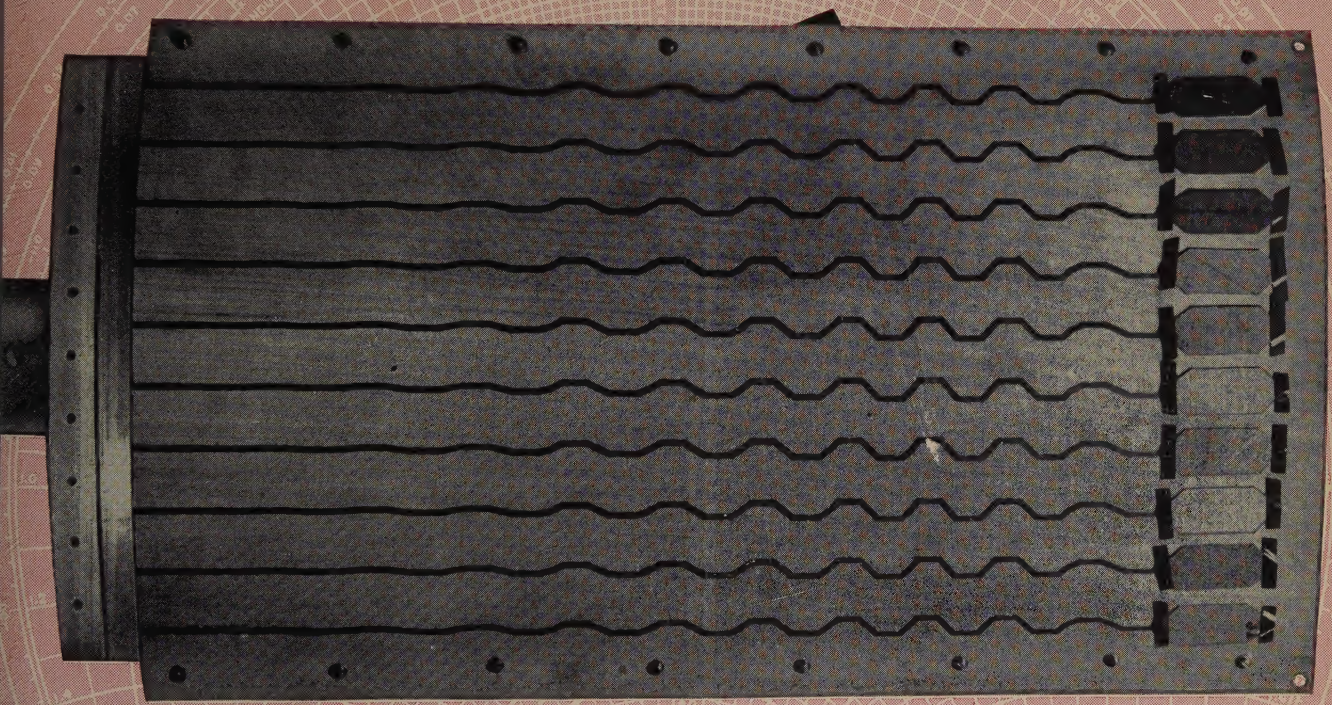
AUGUST 1959
VOL. 2 • NO. 8

- Rotman & Karas — Printed Circuit Radiators: The Sandwich Wire Antenna
- Breitzer & Sard — Low Frequency Prototype Backward-Wave Reactance Amplifier
- Hensperger — The Design of Multi-Hole Coupling Arrays
- WESCON Technical Sessions Program

the microwave journal



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NEXT ISSUE — SLOTTED LINE MEASUREMENTS — MULTI-PORT WAVEGUIDE SWITCHES
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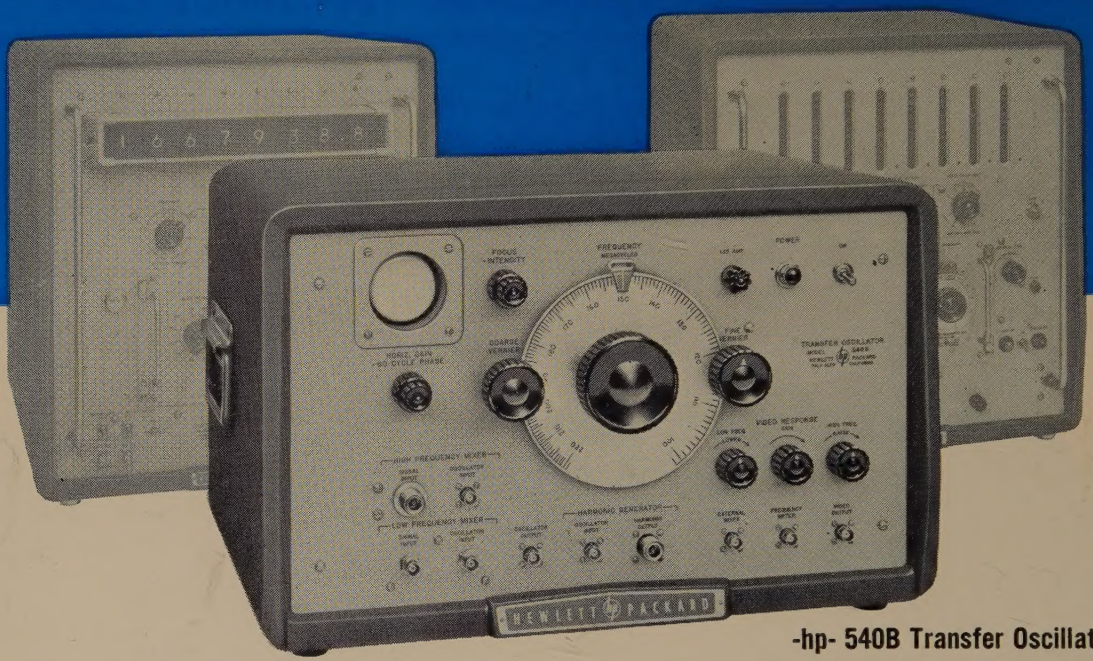

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Extends frequency counter accuracy far into the microwave region. Permits measurement of pulsed, CW, FM, AM or noisy signals. Provides multiple check for positive accuracy. Measures FM deviation. Requires no external mixer or tuning. Eliminates complex setups.

Measurements such as those listed above are made with a convenience and accuracy heretofore associated only with much lower frequencies.

Model 540B is an improved version of the popular hp 540A. It measures frequencies by comparing harmonic output with the unknown and measuring the fundamental on a counter such as hp 524 series. The instrument has a self-contained oscilloscope detector for comparison with unknown frequencies. A precision tuning control permits the oscillator harmonic to be locked with the measured frequency.

Specifications:

Frequency Range:	10 MC to 12.4 KMC
Input Signal:	CW, FM, AM or pulse
Input Signal Level:	Varies with frequency and individual crystals
Accuracy:	Depends on input signal. With stable, noise-free CW signal, accuracy approaches that of frequency counters.
Oscillator Frequency Range:	100 MC to 220 MC (fundamental) Above 12.4 KMC (harmonic)
Stability:	Less than 0.002% change per minute after warmup
Amplifier Gain:	Variable to 40 db or more
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Radio Astronomy is the fundamental science which deals with the radio investigation of space. Each noise source provides its own contribution in the complex maze of microwave energy which surrounds us. A few decades ago, man added his own contribution in the form of communication transmitters, radars, and a vast host of radiators.

Radiometric systems calibrated directly in degrees Kelvin are the basic tools of a Radio Astronomer. A radiometer must be capable of sorting various noise sources available at its input and then amplifying the desired component.

Man-made receiving networks of the conventional variety introduce a considerable amount of internal noise, which is then further amplified. This noise is superimposed on the minute noise signals that are available at the antenna terminals; and hence the radiometer must not only select *noise from noise* at its input, but must identify the input noise signal in the presence of the normally high level of equipment noise.

Most cosmic noise signals are so weak that their total signal contribution represents only a small fraction of the noise power available at the radiometer output.

The state of the art recently established by Ewen Knight for the detection of broadband signals of noise-like character is .01°K, which represents a sorting of noise from noise from noise with an effective detectability 56 db below the total noise level.

Reprints of technical papers describing some of these techniques are available upon request.

Personnel inquiries are welcome.

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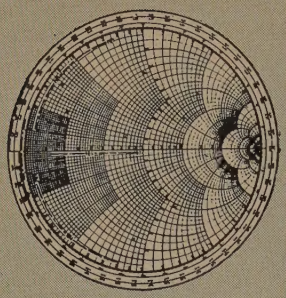

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COVER PICTURE

Printed circuit antenna for Doppler navigational radar. This antenna is intended to be flush-mounted on the cylindrical body of a missile. See Page 29.

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XN	5.40-8.20	1½ x ¾	1032	255.
XB	7.05-10.0	1¼ x ⅝	1031	220.
X	8.20-12.4	1 x ½	1030	175.
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K	18.0-26.5	½ x ¼	1028	295.
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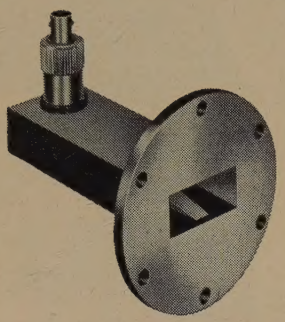

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S	2.60-3.95	3x1½	534	BOLOMETER N-605 THERMISTOR N-333D	1.35 1.5	IN21 or IN23	7¼	110.
C	3.95-5.85	2x1	533	BOLOMETER N-605 THERMISTOR N-333D	1.5 1.5	IN21 or IN23	5⅛	80.
XN	5.40-8.20	1½x¾	532	BOLOMETER N-605	1.5	IN23	4⅛	90.
			542	THERMISTOR N-333D	1.5	1N23	4 15/16	75.
XB	7.05-10.0	1¼x⅝	531	BOLOMETER N-605	1.5	1N23	3¼	85.
			541	THERMISTOR N-333D	1.5	1N23	3¼	65.
X	8.20-12.4	1x½	530	BOLOMETER N-604	1.5		2⅜	65.
			540	THERMISTOR N-336	1.5		2⅜	60.
KU	12.4-18.0	.702x.391	529	BOLOMETER N-604	1.5		2	65.
			539	THERMISTOR N-336	1.75		2¼	95.
K	18.0-26.5	½ x ¼	538	BUILT-IN THERMISTOR	2.0		1¾	150.

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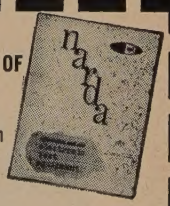

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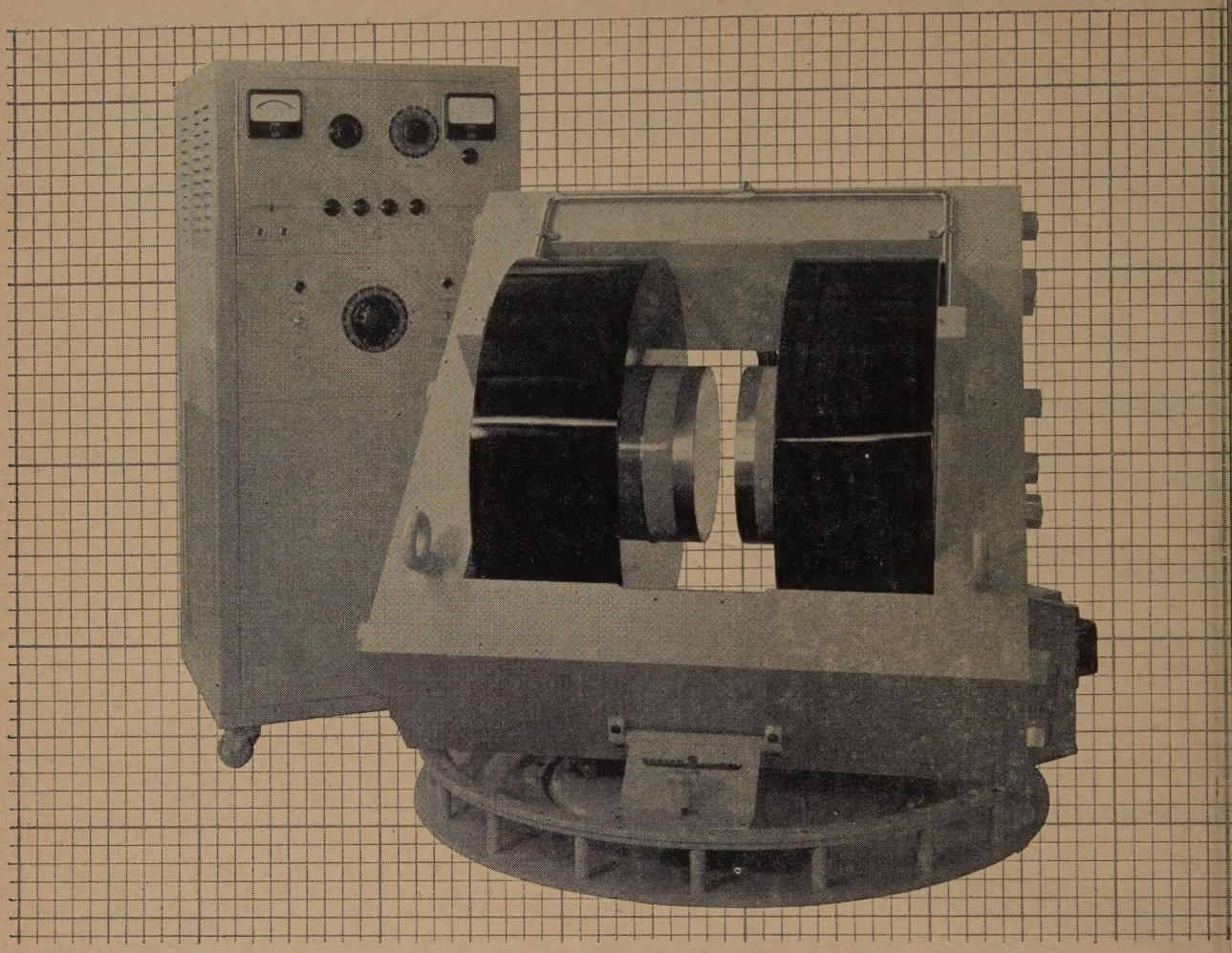

Laboratory magnet systems demonstrating outstanding field uniformity and time stability do not just "happen." Proven **performance** at the installation site is the last link in a long chain of events. The other end of the chain must be firmly secured to specialized **understanding** gained from years of painstaking research and practical experience.

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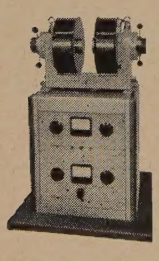

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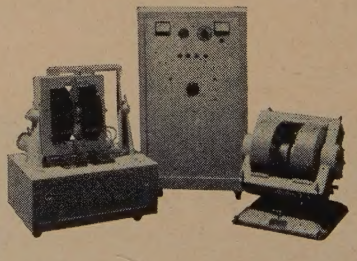

6-INCH MODELS—V-4007-1 AND V-4007

These are high-precision magnets that provide optimum field homogeneity within the inherent possibilities of the 6-inch diameter. They provide ample performance for EPR Spectrometers and many other laboratory uses. The two models each have a different rotational axis: the V-4007-1 vertical, the V-4007 horizontal. The V-4007 magnet can be supplied with shaped axial holes.

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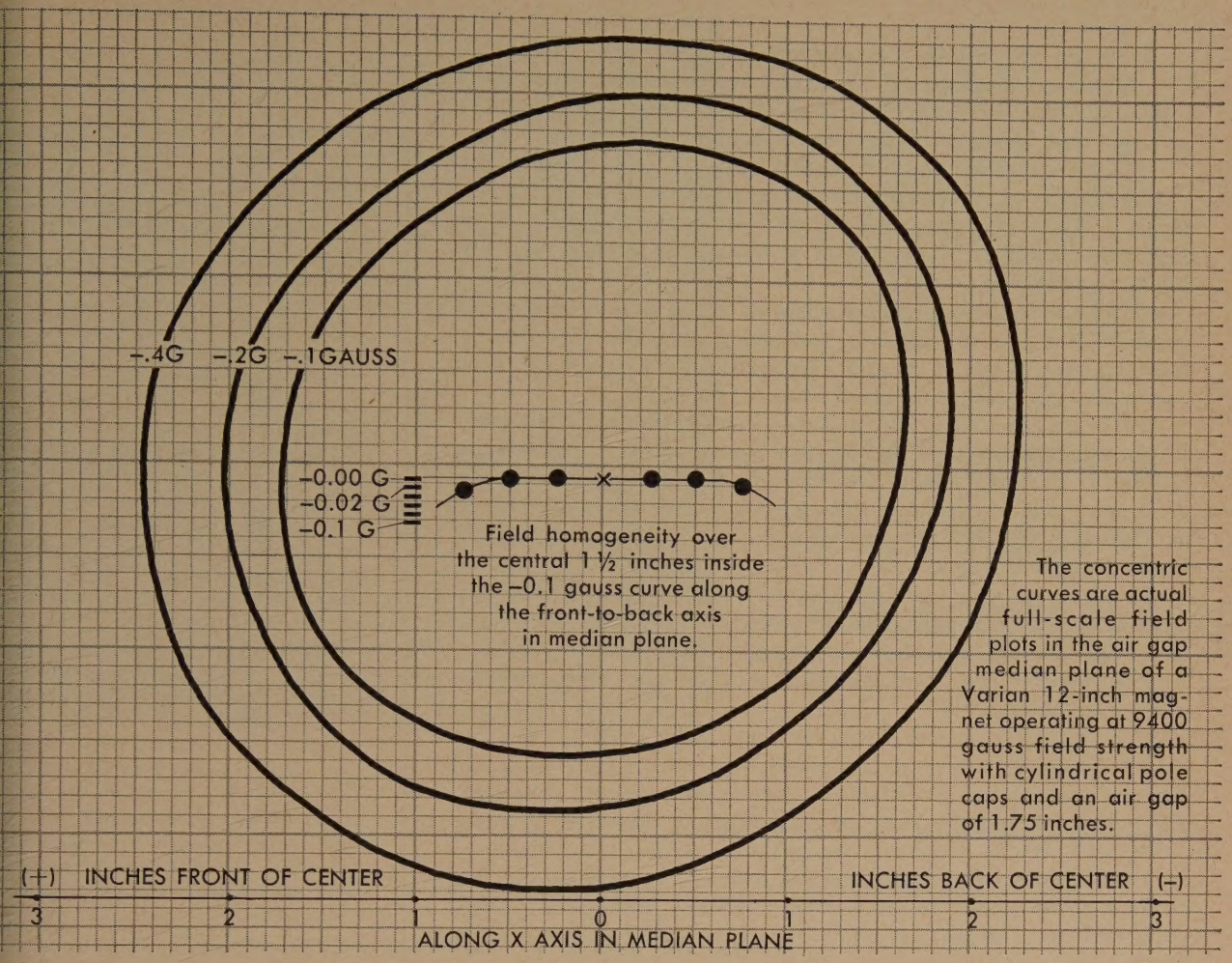
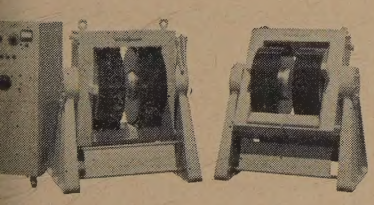

-.4G -.2G -.1GAUSS
-0.00 G
-0.02 G
-0.1 G
Field homogeneity over the central 1½ inches inside the -0.1 gauss curve along the front-to-back axis in median plane.
The concentric curves are actual full-scale field plots in the air gap median plane of a Varian 12-inch magnet operating at 9400 gauss field strength with cylindrical pole caps and an air gap of 1.75 inches.
(+) INCHES FRONT OF CENTER
INCHES BACK OF CENTER (-)
3 2 1 0 1 2 3
ALONG X AXIS IN MEDIAN PLANE

free-world laboratories where they are installed. And Varian Service Engineering encircles the globe to insure continued optimum use and performance from this equipment.

One of Varian's major scientific accomplishments is the NMR Spectrometer which attains resolution of one part in two-hundred million. Associated magnet field homogeneity and time stability are central factors in achieving such unparalleled resolution. Another significant example of Varian's magnet technology is the "shaped hole" technique (just announced) for magnet pole faces. This permits axial passage of light rays and charged-particle beams into the air gap without deteriorating the field uniformity in the sample region. These are end results of Varian's continuing magnet research and development program devoted to product improvement, design of new models and creation of accessory items.



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CIRCLE READER SERVICE CARD 2

FROM THE EDITOR

Since the first Sputnik was sent into orbit, there has been much talk about our engineering shortage. Authoritative voices have commented that more efficient use of our presently available engineering talent would eliminate the shortage.

The latter attitude deserves some attention. It is probably true that the talents of many engineers are not being used to their greatest advantage. It is also true that in certain areas there is much duplication of effort, both within a single organization and between organizations.

The problem of duplication arises in part from the desire for secrecy on the part of competing companies and competing government agencies. Another cause of duplication is the sometimes poor communication between organizations.

There are other areas of inefficiency that can be cited. The main point is that these conditions do exist and every effort should be exerted to eliminate them. However, to try to tamper with this inefficiency and duplication through legislation is an extremely dangerous approach. The cure could easily turn out to be far worse than the sickness.

In all the surveys we have ever seen the engineer has always rated as one of the highest paid members of our society. We have seen other surveys that show engineers leading a very desirable, even an enviable life. And we think about it and ask again why is there a shortage.

One very large reason is that the facts about an engineer's life are not generally known to the public. Up until recent years the engineer was treated somewhat as a second class citizen. The general public has, in large part, always thought of engineers as being a little odd. We, as engineers, like to think that this is not the case.

Consider the following comparison. In the performance of his duties a doctor comes in contact with the lay public who understand what he is doing and why. The same is true of the average lawyer. The average man can understand his function, his purpose, his goal.

What of the engineer? Well, after his years of study he might design the world's best ferrite isolator or the first parametric amplifier at X-band using an infra-red pump. The lay public is unimpressed. In fact it is bored.

The problem, as we see it, is one of education and information or, better yet, good public relations. And it is a long-term program.

One of the logical places to start is with the children. Somehow we must convey to children starting their education that among the more desirable pursuits of life is the engineering profession.

There are many ways of doing this. One thought that comes to mind is the fact that the very companies that need the engineers are in the best position to start the public relations program.

According to some sources the engineering shortage is acute and it will be worse in future years. The natural evolution into a technical way of life will help to increase the supply. But more can and should be done.

We have learned with deep regret that Russel Varian died of a heart attack on July 28, 1959, while vacationing with his family in Alaska. We feel that the scientific world has suffered a great loss with the passing of Rus. We wish to extend our deepest sympathy to the members of his family.

Theodore S. Saad

LETTERS

Mr. Theodore Saad
Technical Editor
the microwave journal
Dear Mr Saad:

I am writing to you in the capac
the student affairs committee chairm
the New York Section PGMTT ch
It is our aim to interest the undergra
student in the microwave field.

A possible approach to this is to
the students receive copies of your exc
magazine. The technical articles would
the student an idea of what is of c
interest in the microwave field. Th
tures section would supply the student
general information about the micr
field. I do not know if the advertiser
pay for *the microwave journal* wou
willing to support either a distributi
the magazine to seniors in the variou
leges or even a more modest proposal
acceptance of subscriptions from unde
uate seniors who are taking a micr
course. There is another possibility
might prove attractive: The issuance
annual volume for the undergra
which would contain a technical s
containing reprints of those technica
icles that would most benefit the
graduate, together with advertising by
companies in the microwave field whi
interested in recruiting these under
ates. If such a venture were underta
should include a listing of fellowshi
assistantships available which may b
plied toward graduate work in micro

If there is any way in which I m
of service in the completion of any s
objectives of yours please feel free t
tact me.

Sincerely yours,
LEONARD KAPLA
New York Univ
College of Engin

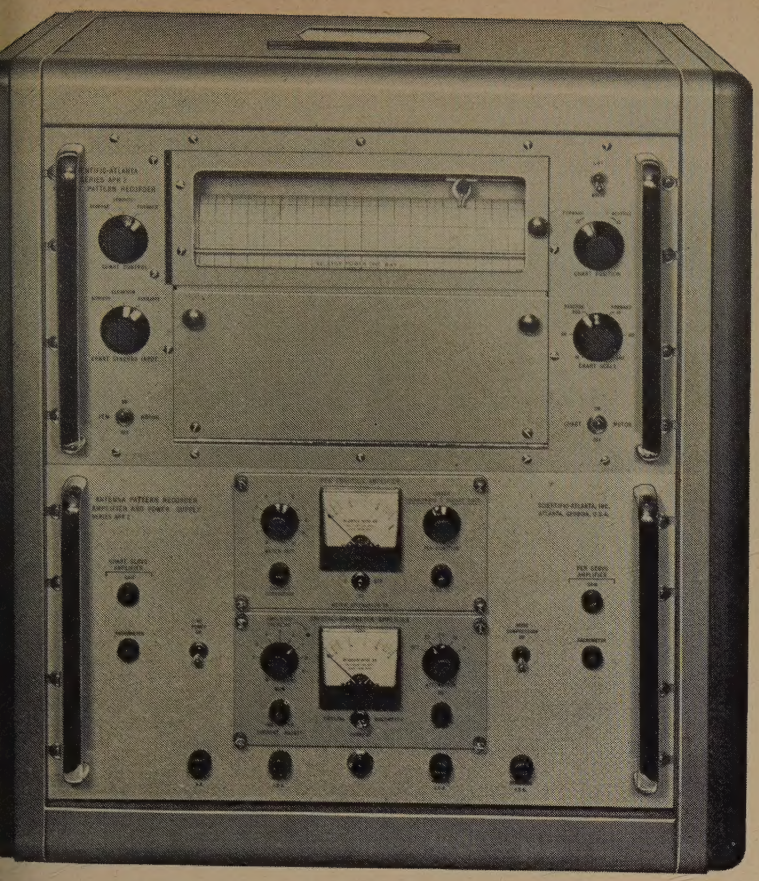
Editors note:

Mr. Kaplan's letter arrived a
offices in very timely fashion, a
one of several that concerns itself
the engineering shortage, and partic
the shortage that plagues the micr
industry. Its coincidence with th
torial at the left only emphasize
problem.

Mr. Kaplan has, in his letter,
some intriguing questions, and su
some positive answers. The sh
of microwave engineers is basic
essence; and we solicit comment o
Kaplan's remarks and further pro
that aim at solving this perennial
lem.

NEXT ISSUE —

In the September issue we will f
the following papers: "The 'M'
Backward Wave Oscillator" by R
Paananen of Raytheon, "A Novel
Slotted Line Measurements" by B
Lamberty of Sylvania, and "Broad
Multi-Port Waveguide Switches
Harry Berland and Fred Vortme
Emerson Electric.



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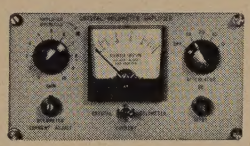
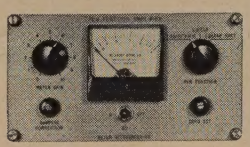


New high gain, low noise bolometer—crystal amplifier



New pen function amplifier

New pen balance potentiometer

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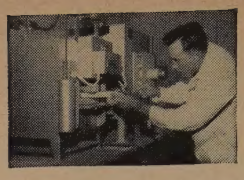
Recipe for ferrite dependability: **SPERRY**



Controlled material is key to the repeatability of ferrites and other solid state devices.

New Ferrite Isolators From Sperry

ELIMINATES EXTERIOR MAGNETS

ACTUAL SIZE
MODEL 44L33

TYPICAL SPECIFICATIONS

	Model 44L11	Model
Frequency Range	1250-1365 mc	1700-2
Isolation: min max	12 db 15 db	
Insertion Loss: min max	0.5 db 0.8 db	
Average Power	10 w	
VSWR: min max	1.05 1.15	
Weight: max	1 lb.	
Dimensions: diameter (max) insertion length	1¼ in. 11½ in.	1
Connectors: input output	Type N male Type N female	Type Type N

New ferrite isolators which eliminate the need for bulky ex magnets are now available in S_c and L bands for relay and systems applications.

These new slim isolators take up no more room than reciprocal uators and are one-fourth the weight and volume of conven isolators.

An entirely new principle uses a small internal magnet, co enough to fit within the coaxial envelope. The whole field of this m is utilized, thereby controlling the ferrite material more effec than is possible with large conventional magnets.

Stray magnetic fields are reduced to a negligible value for most cations. These isolators, with their well protected magnets, will e an extremely long shelf life even when stored in the proxim other magnetic material.

Samples available for evaluation in system breadboards or proto

$4

SPERRY

CIRCLE READER SERVICE CARD 4

SPERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORA*

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"TEAM"

By MARSHALL PEASE
Associate Editor

One of the magic words in these days of massive gineering projects is "team." Every management func- nary worries about this concept — whether or not his partment functions as a team; if not, why not; nether he can convince the upper management that his m is effective. In recent years, we have begun to ar even of teams of companies.

All this leads us to wonder if there is really an agreed d useful meaning to the world. Do different people ean essentially the same thing when they use the word eam"? What does this word really mean? What else es it imply that might be overlooked in its use in eryday business jargon? What are the implications as ll as the connotation?

Danger, of course, exists in the very fashionableness the word. In the present day climate, no one dares gue against the value of building a group into a team. is one of those things that has become universally cepted as being desirable.

None the less, we wonder. We wonder and are some- nat suspicious, particularly because this team concept so universally accepted. We are cynical enough to ve noticed that most of the popular single word con- pts that are accepted as good are either so vague as be meaningless, or that they imply a specific frame reference that is never stated, and sometimes for- tten. In either case, they often carry with them im- ied attitudes that may be quite inappropriate in a ven application.

It is not necessarily bad that a word be general, or at it imply specific conditions. We can usefully dis- ss freedom of the individual without being unduly ncerned about the line between freedom and anarchy. e can talk about education without continually re- nding ourselves that we are not approving education crime. We know, ourselves, what we mean; and we ould have reason to hope that what we say will mean ich the same thing to our listener.

It seems worthwhile, then, to consider for a bit what eam is, and what it is not.

Let us start with the dictionary. The basic modern finition (Oxford Universal Dictionary, 3rd Ed.) is follows: "A set of draft animals; two or more oxen, rses, dogs, etc., harnessed to draw together." This not a very good start! What engineer would accept comparison to a draft animal? Let us quietly pass on. Next we see that a team is "a number of persons asso- ted in some joint action; now especially a definite mber of persons forming a side in a match . . ." This better; in fact it more or less fits the picture.

If we think a little more on this, however, we begin to wonder. For one thing, it implies a competition. Where the term is used in industry, there is sometimes competition. Companies combining in a team for the sake of a bid are, in fact, competing against other such associations. An engineering department which may or may not have the "team spirit" is, in a sense, competing against its counterparts in other companies. But it should be noted that the word is used more generally than in the competitive sense. It implies, if we read it correctly, a working together that transcends any immediate competition.

This is, maybe, a trivial objection. Let us look further.

It is a truism of athletics that, to call an athlete a star, does not necessarily infer that he possesses much or any team spirit. The individual performer, if he is good enough to be called a "star," probably has, in that very fact, an extra handicap to overcome to become a good team member. He is, in the first place, absorbed in his own performance. Secondly, his teammates would be other than human if they did not view him as something of a threat to their own self-esteem.

Some degree of mediocrity, then, is of considerable help in achieving good team spirit.

A more respectable name for this state of affairs is "conformity." Some degree of conformance in an engineering organization is, of course, necessary; but if the organization is to accomplish anything out of the ordinary, it must have in it some people who are able to think in non-conforming ways.

Invention is a lonely business. No team thinks up a new engineering principle. No committee generates, as a group, a new idea. It can, at best, put co-ordinated effort into exploiting an idea that is the brainchild of some single individual.

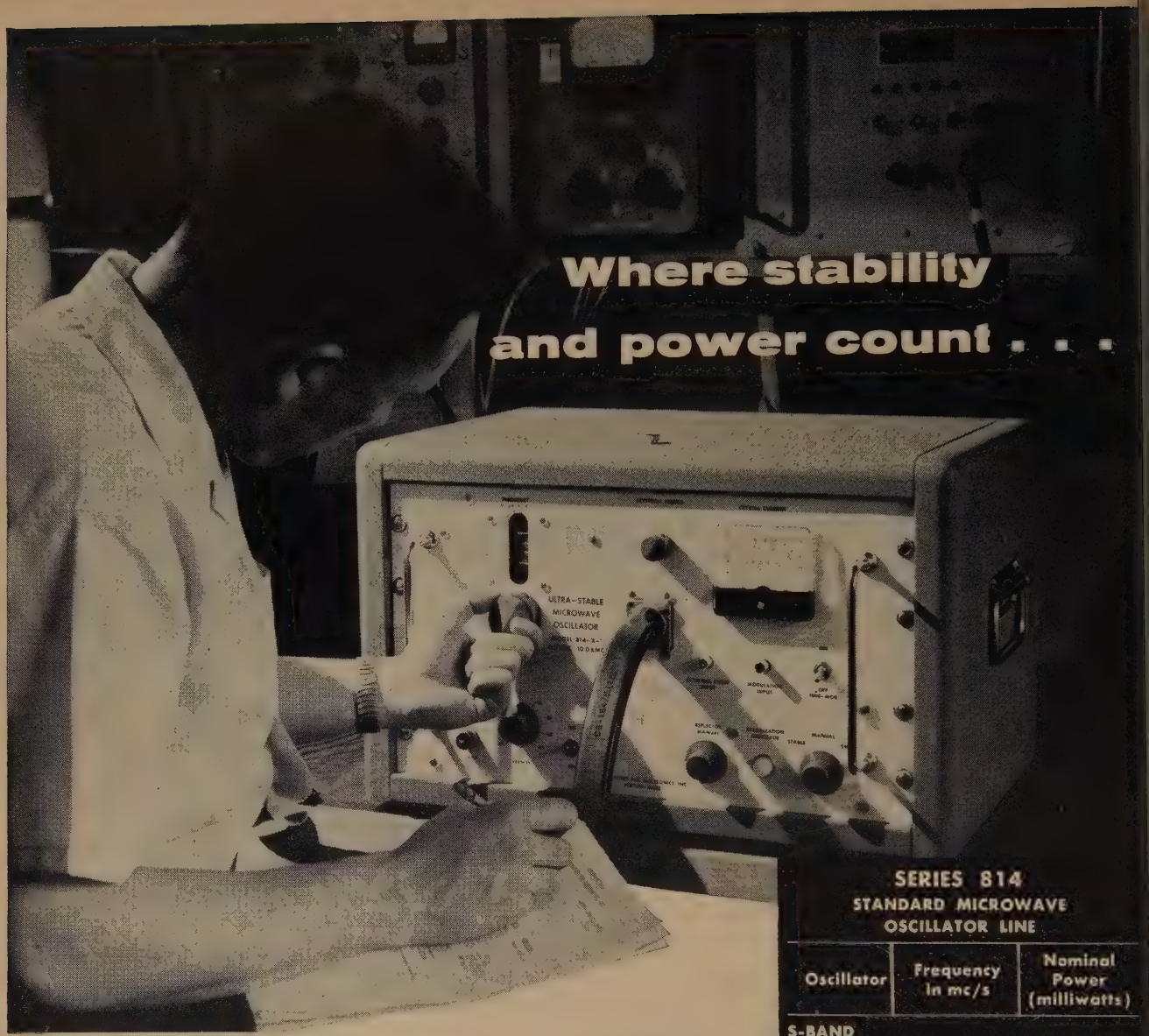
This aspect of engineering, then, is completely submerged when we talk of the team. The two areas of organizational accomplishment — the group area epitomized by the word "team," and the individual area of creativity — are not mutually exclusive. Both types of activities do go forward in the same organization; but they are totally different aspects. While considering the one, we should not lose sight of the other.

This is a limitation on the "team concept" — it is not an objection. But there are other ways in which the team concept may actually mislead us in the aspect which it purports to describe.

When we speak of "team," we think perhaps of college football. One of the key factors in the activities of such teams is the fact that all of the plays are called by one single individual on the team. If the season happens to be spring, we may think, instead, of professional baseball. In this case, the key decisions are not made by any member of the team at all, but by the manager in the dugout. Or, if we are types to whom such active examples tend to be exhausting, we may think of the game of bridge, where there is no line of authority at all, but where there is an elaborate and ritualistic method of, ideally, reaching a proper joint decision.

So, as soon as we start thinking of teams, we come to the question of how the team, if it is to be a team, will handle the question of decisions.

Here, we have something that is very far from being trivial. It appears, rather, to be the very essence of what is meant by the word "team." To say, "They are a



Where stability and power count . . .

If you have an application where stability and power output requirements are *really* exacting (production or testing of microwave components of air defense missile systems, for example), it's to your advantage to investigate LFE Series 814 Microwave Oscillators. They have been tried and proven in all fields of microwave work over a period of 7 years.

STABILITY — Series 814 Oscillators are ultra-stable. Average short term frequency stability (residual) is five parts in 10^8. Average long-term stability is one part in 10^6. A self-contained invar dual mode reference cavity and AFC loop insures this performance. When a frequency is selected via the reference cavity, and the Klystron locked to it, stability characteristics conform to the above specifications. Klystron is conveniently locked by observing a stabilization indicator light bringing about great ease in operation.

POWER — The table on the right tells the power story. Nominal powers available in standard Series 814 Oscillators range from 20 to 500 milliwatts. Outputs up to 1.5 watts are available on special order.

SPECTRUM COVERAGE — Series 814 is a complete line, covering the microwave spectrum from 2500 to 26,000 megacycles.

AMPLITUDE MODULATION — Up to 15% by internal 1 kc oscillator, jack on front panel for external modulation.

FREQUENCY MODULATION — Deviation up to 0.01% of selected frequency via external connector.

SERIES 814
STANDARD MICROWAVE OSCILLATOR LINE

Oscillator	Frequency in mc/s	Nominal Power (milliwatts)
S-BAND		
814-S-1	2500-3050	75
814-S-2	2950-3600	80
814-S-3	4200-4800	70
C-BAND		
814-C-1	5100-5900	60
814-C-2	5800-6600	65
814-C-3	6300-7125	55
814-C-4	7125-8125	80
814-C-5	7500-8500	90
814-C-11	5700-6300	200
814-C-12	6200-6900	250
814-C-13	6800-7400	300
X-BAND		
814-X-1	8500-10,000	80
814-X-2	9000-10,500	55
814-X-3	9800-11,200	70
814-X-4	10,500-11,700	80
814-X-21	8500-10,000	500
K-BAND		
814-K-1	13,000-14,000	20
814-K-2	16,000-17,000	40
814-K-11	12,000-13,800	85
814-K-12	14,000-16,000	25
814-K-13	15,500-17,500	30
814-K-21	12,800-14,500	100
817-K-25	24,000-26,000	30

WRITE FOR BULLETIN 814-A

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CIRCLE READER SERVICE CARD 5

od team" means, it seems to us, that they have solved e question of authority in such a manner that they do nstitute an effective organization. Conversely, when a oup is not an effective team, we can always describe e failure as a lack of agreement on decisions.

It may be argued that ineffectiveness can be the nsequence of bad decisions fully agreed upon. This, wever, is simple stupidity or ignorance, not a failure function as a team. It may, in fact, represent the imate manifestation of hyperactive team spirit. We shall, present purposes, ignore this unfortunate possibility.

In stating that team failure is a consequence of a ilure to agree on decisions, we find ourselves face to e with the problems of what is a decision, and what nstitutes agreement. If the question is one of choos- between a finite number of distinct and definite pos- ilities, there is no problem. Somehow a selection is ade, and everybody conforms to that choice or gets ed — all very simple.

Most important decisions, however, are not made at way — which, perhaps, is why they are important. ually the choices available are vague and undefined, presenting an attitude rather than an action. The re- onse to a number of available choices is much more an a simple "yea" or "nay." There are all sorts of sponses possible — from an enthusiastic leap onto e bandwagon down through all the intermediate at- udes to a conscious determination to go along with ly the "letter of the law." While the extremes are y to spot, it becomes tricky in the intermediate cases decide just what degree of concurrence has been ob- ned. This is particularly so when it is often impos- le to state explicitly just what the decision itself was!

Under these circumstances, then, one wonders just at is the significance of the team concept. Certainly it an intangible. More than that, it is an intangible t is based on intangibles.

Furthermore, it may lead one to look in wrong direc- ns for the reasons for breakdown in team effective- ss. Usually if a team is not effective there is at least trong implication that the solution lies in a change heart in the team members — or a change of team mbers. The quarterback or manager may be criticized failing to inspire the proper loyalty in the team, never for acting as a quarterback or manager. Yet root problem involved in the failure of an engi- ering group to function as a team may, in fact, be in decision making procedure itself. The failure may the result of the quarterback quarterbacking in areas ere he should not.

It is a truism that engineering is an authoritative ld. Given an engineering problem, there are many swers that will not work, and only one or a few that ll. No matter however overwhelming the majority t favors a given answer, if it is not going to work — won't. Nature is singularly unimpressed by majority tes. This fact puts tremendous emphasis on the judg- nt of those who, by virtue of having had applicable perience, should be in a position to make the best ess.

This is in contradistinction to what we might call man- rial-type problems. Rarely does a wrong decision on such problems lead to disaster. The accumulation of many such wrong decisions may lead to bankruptcy, but no single such error is likely to do more than splash a little red ink around. Often enough it is not even clear whether or not the decision was wrong. But there is very little arguing with a process that does not work, or a design that does something else than what was intended.

The significant aspects here are the truths — and they are clearly true — that first, engineering decisions must be made by individuals, and second, the proper choice of the individual who is to make the decision depends on the problem. A young engineer fresh out of school may have more specific and applicable experience for a given problem than his boss's boss. If the organization is to function effectively, that engineer should make that decision, and those upward in the hierarchy should be content to allow him to do so.

Where this is not done — and it is also a tricky problem to know whether this kind of delegation is or is not being properly done — then there must be a failure of the team spirit. If the young engineer has the best answer, only to have his seniors decree a different one, then his attitude toward the team will certainly be affected.

He does not deserve to be called an engineer who will go along happily with an engineering decision that his superior has made and which he believes to be wrong. An organization of people worthy of being called engineers will most certainly fail to be a team if the structure of authority and decision does not adjust itself to the realities of the experience and talent within the group.

Yet it seems to us that to call such a situation a lack of team spirit is to dodge the actual problem. So diagnosed, the obvious remedy seems to be in the ways by which those in authority can evoke better loyalty. In such a case, the lack of team spirit is a symptom, not a cause. If the symptom be treated while ignoring the cause, then, certainly, the results will be less than desired.

Where does this leave us? We do not suggest that the word "team" is invariably a bad one. We must concede that it is a useful word in describing certain aspects of the functioning of an organization; but we also maintain that it describes only some of the aspects, not all. Particularly and most importantly, it does not describe the aspect of creativity. We can suggest that to some extent, the aspects it includes are antipathetic to creativity. We suspect that, were the ideal engineering team actually put together, it would be a singularly unimaginative group.

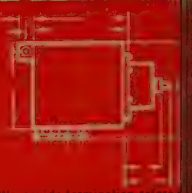
We also suggest that there is danger in the label "team" in that it describes a symptom to the possible confusion of the cause. If the label is used with the full awareness of this possibility, the difficulties will be minimal. If, instead, it is used as a bit of jargon, as a tag that replaces true thought, the concept can be very dangerous.

"Team" is a useful word; but precisely because it has become so fashionable, it is one that should be used with some caution.

Frequency Range: 7.5-8.5 kmc
Bandwidth at 3 db points: 8 mc min.
Bandwidth at 70 db points: 75 mc max.
Insertion Loss: 2 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TE_{011}

Type: Absorption type wavemeter
Frequency Range: 15.8-17.2 kmc
Loaded Q: 7000 min.
Absorption Dip: 10% min
Calibration: Direct reading drum, 1 mc markers
Frequency Resolution: .100 inch per mc
Accuracy at 70°F: ±.01% min
Stability: ±.02% 70°F ±70°F
RF Connectors: UG-419, U

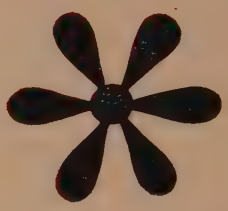
Frequency Range: 8000-8950 mc
Bandwidth at 3 db points: 9 mc min.
Bandwidth at 35 db points: 30 mc max.
Insertion Loss: 2 db max
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TE_{011}

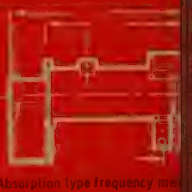


Type: Waveguide termination refere
Frequency Range: 5925-6425 mc
Loaded Q: 1000-1400
Frequency Resolution: Can be set to
Accuracy at 70°F: ±.005% at 70°F
Stability: ±.01% over temperature
of 70°F ±70°F
RF Connectors: RETMA or UG-344/U
Construction: Invar cavity and tunin

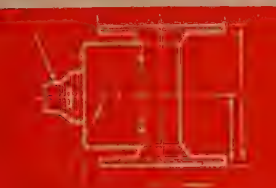
Frequency Range: 8950-10,000 mc
Bandwidth at 3 db points: 9 mc min.
Bandwidth at 35 db points: 35 mc max.
Insertion Loss: 3 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TE_{011}

Type: Plug in Reference cavity, transmission type
Frequency Range: Fixed tuned in band of 5.7-6.1 KMC
Loaded Q: 4000 ± 10%
Transmission Loss: 3 db max.
Accuracy at 70°: ±.005%
Stability: ±.01% over temp. range of 0°C to 66°C
RF Connectors: Mates with 1½ x ¾ waveguide



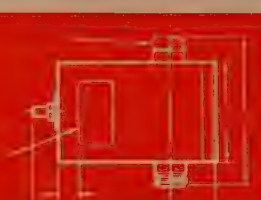


Type: Absorption type frequency me
crystal detector
Frequency Range: 8.3-9.7 kmc
Loaded Q: 5000 min.
Absorption Dip: Approximately 1 dB
Calibration: Direct reading spiral dia
markers
Frequency Resolution: min. of 1/32"
Accuracy at 70°F: ±.01%



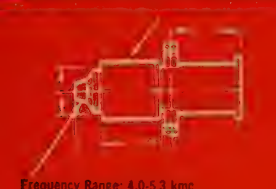
Frequency Range: 2700-3150 mc
Bandwidth at 3 db points: 4.5 mc min.
Bandwidth at 30 db points: 40 mc max.
Insertion Loss: 1.5 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 1
Mode: TE_{101}

Frequency Range: 2.0-2.5 kmc
Bandwidth at 3 db points: 5 mc ±1.5 mc
Bandwidth at 60 db points: 60 mc max.
Insertion Loss: 3.5 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TEMλ/4



Frequency Range: 2700-2950 mc
Bandwidth at 3 db points: 4 mc min.
Bandwidth at 40 db points: 20 mc max.
Insertion Loss: 3 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1 (screwdriver adjustment)
Mode: TEM λ/4

Type: Transmission type cavity
Frequency Range: 7100-8500 mc
Loaded Q: 1500 ±20%
Transmission Loss: 6 db max.
Calibration: Counter dial versus freq
Accuracy at 70°F: ±1 mc
Stability: ±2 mc over temperature
of 70°F ±70°F
RF Connectors: UG-51/U



Frequency Range: 4.0-5.3 kmc
Bandwidth at 3 db points: 15 mc min.
Bandwidth at 30 db points: 200 mc max.
Insertion Loss: 3.5 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 1
Mode: TEM 3λ/4

Frequency Range: 5.3-7.0 kmc
Bandwidth at 3 db points: 15 mc min.
Bandwidth at 30 db points: 200 mc max.
Insertion Loss: 2 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 1
Mode: TEM 3λ/4

Frequency Range: 5400-5900 mc
Bandwidth at 3 db points: 10 mc min.
Bandwidth at 40 db points: 120 mc max.
Insertion Loss: 2 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 2
Mode: TE_{101}
RF Connectors: Type BNC male modified

Frequency Range: 10.8-11.6 kmc
Bandwidth at 3 db points: 9 mc min
Bandwidth at 35 db points: 35 mc ma
Insertion Loss: 3 db max.
Input VSWR (with matched load): 1.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TE_{011}

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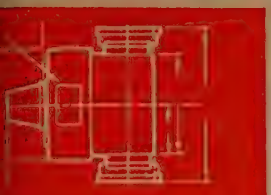
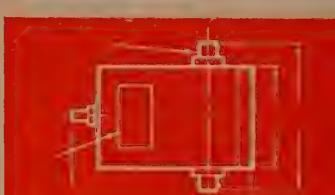


...y Range: 8.5-9.6 kmc
...h at 3 db points: 8 mc min.
...h at 30 db points: 70 mc max.
...Loss: 2 db max.
...WR (with matched load): 1.5 max.
...of Resonant Sections: 2
...of Tuning Controls: 1 (10 turn dial or ...iver control)
...111

Frequency Range: 3.2-4.0 kmc
Bandwidth at 3 db points: 5.5 ±1.5 mc
Bandwidth at 60 db points: 60 mc max.
Insertion Loss: 4 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TEMλ, 4

Frequency Range: 1200-1400 mc
Bandwidth at 3 db points: 8-10 mc
Bandwidth at 35 db points: 35 mc max.
Insertion Loss: 2 db max.
Input VSWR (with matched load): 1.5:1 max.
Number of Resonant Sections: 3
Number of Tuning Controls: 1
Mode: TEM λ/4
Calibration: Can be furnished with counter dial

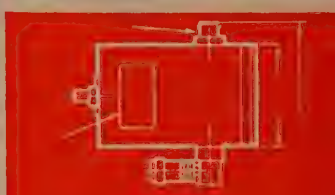


Frequency Range: 2700-2950 mc
Bandwidth at 3 db points: 5 mc min.
Bandwidth at 50 db points: 40 mc max.
Insertion Loss: 3 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1 (screwdriver adjustment or counter dial)
Mode: TEM λ/4

...y Range: 10,000-10,800 mc
...h at 3 db points: 9 mc min
...h at 35 db points: 35 mc max.
...Loss: 3 db max.
...WR (with matched load): 1.5 max.
...of Resonant Sections: 4
...of Tuning Controls: 1
...Edit

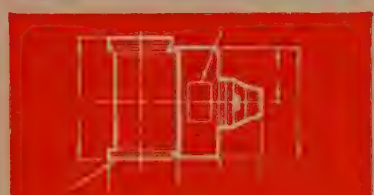
Frequency Range: 4.4-5.0 kmc
Bandwidth at 3 db points: 37 mc min.
Bandwidth at 17 db points: 150 mc max.
Insertion Loss: 1.0 db max.
Input VSWR (with matched load): 1.5:1 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 1
Mode: TE_{101}
Calibration: Direct channel markings every 10 mc

Type: Panel mounted frequency meter and metering circuit
Frequency Range: 2.3-3.5 kmc
Loaded Q: 1000 min.
Calibration: Micrometer versus frequency
Frequency Resolution: 78 kc/vernier div. low end, 125 kc/vernier div. high end
Accuracy at 70°F: ±.01%



Frequency Range: 2700-2950 mc
Bandwidth at 3 db points: 5 mc min.
Bandwidth at 50 db points: 40 mc max.
Insertion Loss: 3 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1 (screwdriver adjustment)
Mode: TEM λ/4

...y Range: 7100-8500 mc
...h at 3 db points: 10 mc min.
...h at 30 db points: 100 mc max.
...Loss: 2 db max.
...WR (with matched load): 1.5 max.
...of Resonant Sections: 2
...of Tuning Controls: 1
...111
...on: Counter dial versus frequency

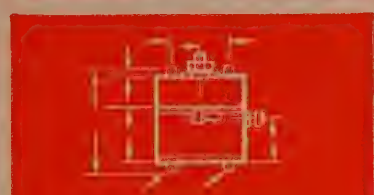


Frequency Range: 7.5-8.5 kmc
Bandwidth at 3 db points: 10 mc nominal
Bandwidth at 28 db points: 75 mc max.
Insertion Loss: 2 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 2
Number of Tuning Controls: 1
Mode: TE_{11}
Calibration: Counter dial vs. frequency (optional)

Frequency Range: 11.6-12.5 kmc
Bandwidth at 3db points: 9 mc min.
Bandwidth at 35 db points: 35 mc max.
Insertion Loss: 4 db
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TE_{011}

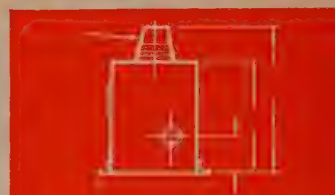
Frequency Range: 7.5-8.5 kmc
Bandwidth at 3 db points: 10 mc max.
Bandwidth at 35 db points: 75 mc
Insertion Loss: 1 db max.
Input VSWR (with matched load): 1.3 max.
Number of Resonant Sections: 2 ea. channel
Number of Tuning Controls: 1 per channel
Mode: TE_{011}
Calibration: Counter dials vs. frequency

...y Range: 2700-2950 mc
...h at 3 db points: 10 mc ±2 mc
...h at 40 db points: 120 mc max.
...Loss. 2.5 db max.
...VR (with matched load): 1.5 max.
...Resonant Sections: 2
...Tuning Controls: 2
...M λ/?
...tors: 53-135 microdot



Frequency Range: 5350-5905 mc
Bandwidth at 3 db points: 19 mc min.
Band width at 30 db points: 52 mc max.
Insertion Loss: 3.5 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TEM λ/4
Calibration: Counter dial optional

Frequency Range: 2700-2950 mc
Bandwidth at 3 db points: 8 mc min.
Bandwidth at 25 db points: 28 mc max.
Insertion Loss: 4 db max.
Input VSWR (with matched load): 2.0 max.
Number of Resonant Sections: 3
Number of Tuning Controls: 1 screwdriver adjustment



Frequency Range: 2.5-3.2 kmc
Bandwidth at 3 db points: 4 mc min.
Bandwidth at 60 db points: 60 mc max.
Insertion Loss: 3.5 db max.
Input VSWR (with matched load): 1.5 max.
Number of Resonant Sections: 4
Number of Tuning Controls: 1
Mode: TEMλ/4

Ward William & Company, Advertising

...neter or filter requirement

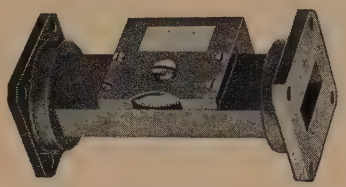
From over 400 microwave frequency meter and tunable band pass filter designs, your requirement can be filled easily and quickly. If the unit for your application is not already in stock, it can be produced readily by *modifying* one of the hundreds of Frequency Standard meters or filters now *available*. This means both minimum lead time and development costs.

Send your technical requirement for a prompt analysis or meet with our staff and discuss your specific problem.

CIRCLE READER SERVICE CARD 6

Literature on Standard Products is Available on Request

MINIATURE—LIGHTWEIGHT
ATTENUATORS



TYPE 609

NEW

X BAND
ALUMINUM
3½ OZ. WEIGHT

TYPE 611-711

Calibrated 5.0 db Points Centerband frequencies.

TYPE 609 is NEW — A small, lightweight, rugged, highly accurate attenuator designed to provide accurate settings under conditions of shock and vibration. The dial can be securely locked. Finish is Iridite. Weight 3-1/2 ounces.

Excellent shielding properties, low 1.15 maximum VSWR value, 0.3 db. maximum insertion loss and a range of 30 db. combine to provide exceptional electrical operation in a small unit.

TYPES 611 - 711—The attenuation range of these units is 35 db. calibrated at 9.60 and 15.0 Kmc/Sec. Maximum insertion loss is 0.3 db. with VSWRs not exceeding 1.15. Construction is brass, gold plated.

SHIELDED — RUGGED — ACCURATE

Type	Unit Price	Frequency Range Kmc/Sec	Attenuation Range	Waveguide Type	Length Inches
609	$50.00	8.2-12.4	.30 db	RG-67/U	3.50
611	75.00	8.2-12.4	35 db	RG-52/U	3.75
711	75.00	12.4-18.0	35 db	RG-52/U	4.00

LEADERS IN ATTENUATION DEVICES

COMPLETE CATALOG AVAILABLE

WAVELINE INC.
CALDWELL, NEW JERSEY

CIRCLE READER SERVICE CARD 7

TO OUR READERS

In many cases "the microwave jour is being sent to your home address order to lessen the burden on comp mailroom facilities.

INDUSTRY NEWS

NARDA OPENS NEW DIVISION

Executives of the Narda Microw Corporation of Mineola, L.I., were h July 8, 1959, to a group of editors the nations leading business and tec cal press, and to representatives c number of Narda's major customers a luncheon in the Sky Club, Ga City, L.I.

The occasion was the announcer by Dr. John C. McGregor, chairma the board, and president of the firm the formation of a new High Po Electronics Division to design and b a new line of products for microw communications systems. This new will be comprised of much larger u than the company's present range components and test equipment, and carry a higher unit price-tag. Dr. Gregor estimated that the pote market for the new line could do Narda's present annual sales volume

Dr. McGregor added that the C pany's sales for the fiscal year e June 3, 1959, were slightly above million, representing a gain of over last year.

Speaking also at the luncheon Dean Francis K. Ballaine of Ade College, Garden City. Dean Ball director of the college's Advanced I agement Program, stressed the import of cooperation between industry educational institutions in the dev ment of more effective managers industry, and pointed out the su that such efforts have had in the gr of small business firms on Long Is

The visitors also toured Narda's m facturing and testing facilities, and nessed a demonstration of the product of the new division. This new microwave modulator, model 1 which provides a means of testing netrons and various other micro components.

• • •

1959 PGED MEETING

The fifth annual electron devices ing sponsored by the Professional Grou Electron Devices (PGED) of the Ins of Radio Engineers, will be held Oc 29 and 30 at the Shoreham Hotel, W ington, D.C., it has been announce William J. Pietenpol, of Sylvania El Products Inc., chairman of the general mittee for the conference.

Dr. Pietenpol said abstracts of tech papers proposed for the conference s be submitted by July 31 to the tech

ogram chairman, John A. Hornbeck, Bell elephone Laboratories, Murray Hill, N.J. ubject matter of the proposed papers ould concern developmental techniques d devices, such as electron tubes and miconductors, rather than basic research circuit applications.

In addition to Dr. Pietenpol and Dr. ornbeck, members of the General Committee for the October meeting include: ice Chairman, Dr. W. R. Sittner, Sperry nd Corp.; Publications Chairman, Dr. L. Steele, Hughes Aircraft Co.; Local rangements Chairman, Dr. R. T. Young, ., Diamond Ordnance Fuze Laboratories; blicity Chairman, J. J. Lanigan, Sylnia Electric Products Inc.

Nearly 1,200 members attended the 1958 ctron Devices Meeting, which was held the Shoreham Hotel on October 30 and . The agenda included 64 papers rang- over the entire field of electron devices.

• • •

CONTRACT AWARD TO PHILCO

A $75,000 research contract for a study a new electronics technique known as incushion radar" has been awarded to ilco Corporation's Government & Indusl division by the USAF Rome Air Deopment Center, Rome, N.Y.

Details of the new radar system are ssified as secret, but the technique should vide more reliable radar detection of air space targets at long ranges and more ailed information concerning the posin and identity of the targets.

• • •

NEW R/D, MANUFACTURING FIRM FORMED

Applied Technology, Inc., a new firm for histicated electronics systems research, elopment and manufacture, has been med in Palo Alto, Calif., with Dr. Wiln E. Ayer as president and Peter D. am as vice president.

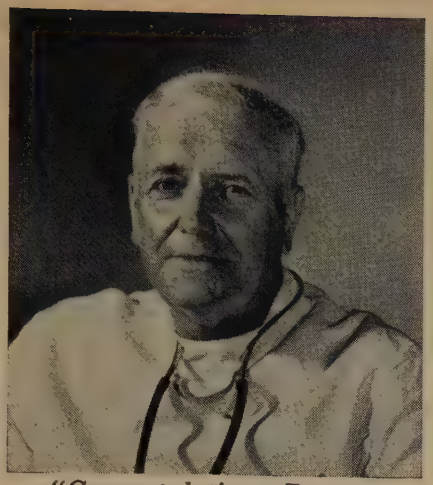
The new company will specialize in very adband microwave systems using travel-wave and similar beam-type tubes for h applications as countermeasures, radio onomy receivers, reconnaissance receiv- systems, and other advanced military civil electronics.

Ayer and Strum were formerly with nger Associates, Palo Alto, where Ayer vice president and director of engineer- and Strum was supervisory engineer.

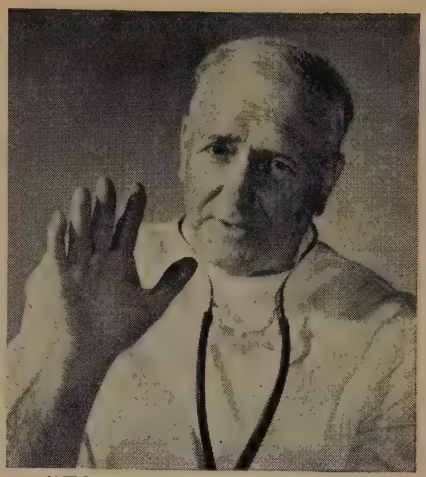
Prior to joining Granger 1957 Ayer spent years with Stanford University in the vice-sponsored applied electronics pron as project engineer, group leader and d of the Systems Development Section. viously he was a design engineer with ckay Radio and Telegraph Co. in Palo o for six years after wartime service as Navy radar officer.

Ayer received his B.A., M.A. and Ph.D. electrical engineering from Stanford Uniity. He is a registered electrical engir in California, a senior member of the titute of Radio Engineers and a member Tau Beta Pi and Sigma Xi.

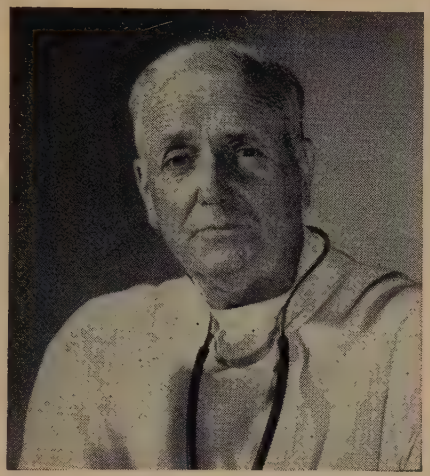
(*Continued on Page 24*)



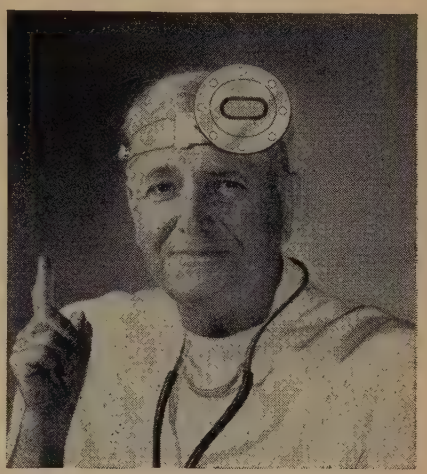
"Congratulations, Doctor, that was a remarkable operation . . ."



"Thank you . . . but I'm not really a doctor . . . I'm a microwave engineer."



"Oh? And do you think everyone should be a microwave engineer?"



"No . . . I think people should decide for themselves . . . But I do think all microwave engineers should use . . .

MICROWAVE ASSOCIATES WINDOWS

. . . they insure mechanical ruggedness, reliable, low-loss hermetic sealing, resistance to wide cycling of temperature and pressure. Typical applications:

COMMON CARRIER (4000 Mc) Mica pressure windows built on a standard flange. Ready to install in any system.

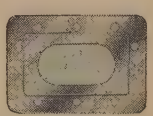
MICROWAVE RELAY LINK (6000 Mc) Mica pressure seals. All-weather protection for systems from Texas to the Arctic. Built on a standard flange.

INVAR REFERENCE CAVITIES — Glass-Kovar pressure windows especially designed using *Flexframe** construction to resist breakage.

A complete line of windows, including designs for these specific areas is described in our new bulletin 59W. Included are mechanical and electrical characteristics and improved testing procedures.

We will design and deliver microwave windows to your specifications. Please write or call:

**MA's new shock-resistant window-mount.*



MA-1474

MA-1452

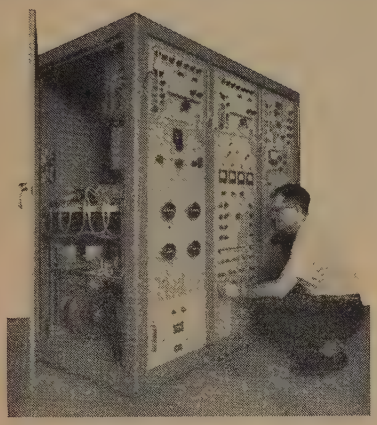
MA-904

MICROWAVE ASSOCIATES INC.

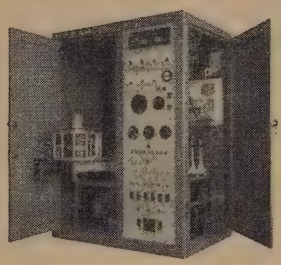
BURLINGTON, MASSACHUSETTS BROWNING 2-3000

WORK IN PROGRESS AT LEVINTHAL

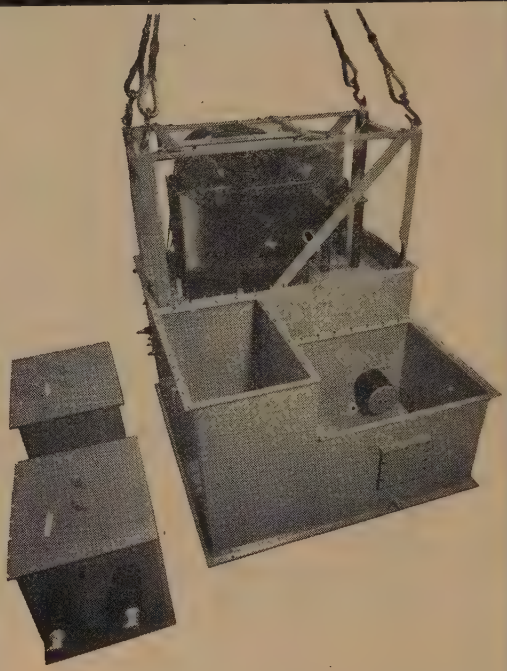
Among the various projects on the work docket in the Levinthal Stanford Industrial Park plant, these samples give a hint of the breadth of capabilities existing here.



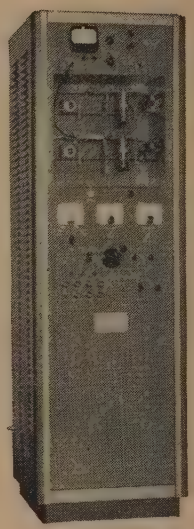
Model 229T. Built for Rome Air Development Center, this combination signal source covers the spectrum of 1 to 11 kmc in four bands. Useful for component-laboratory or antenna-range application, the instrument features internal pulse, square-wave, and frequency modulation; includes extensive provisions for stability. Separate units for each band are also available as Model 231T.



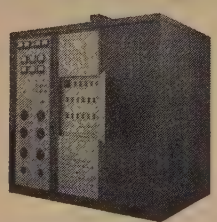
Model 74T. Destined for scatter-communications use, this 1-kw transmitter contains an Eimac 3K2500SG klystron and functions over the band 1700 to 2400 mc. Unit, complete as shown, offers convenience of having klystron on drawer-type mounting. Delivery will be made to Westinghouse.



Special pulse-transformer assembly for Litton Industries' Power-Tube Division combines standard Levinthal 1Q3 Pulse-Current Transformer (lower right) with specially designed 250-kv 234-amp 17:1 klystron pulse transformer, rated at 58.5 megawatts peak and 193 kw average power. Tank has provision for installation of peak-reading voltmeter. At left are Levinthal 3-henry 4.5-amp 35-kv (peak) charging chokes for the same installation.



Model 99P. An 18- to 40-kmc 1-mw signal source for Douglas Aircraft Company. Designed for countermeasures, this instrument also serves as a general-purpose laboratory device.



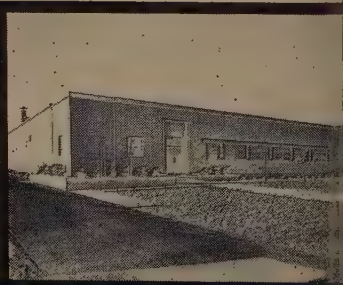
Model 250T. Here is a combination 0- to 75-kv 250-ma klystron beam supply and 0- to 44-kv modulator supply for Eitel-McCullough Inc. to use in testing X757 klystrons. On the same contract with Bendix Radio, Levinthal is producing 12 MIL-spec modulators, also for Air Force DEWline Sentinel radar.

LEVINTHAL ELECTRONIC PRODUCTS, INC.

Stanford Industrial Park Palo Alto 7, California

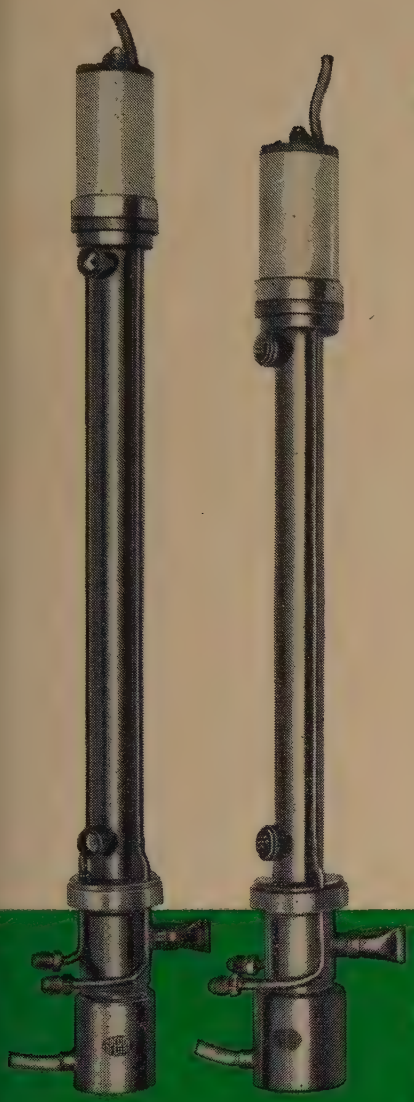
Major products of the Levinthal Equipment Division are transmitters, modulators, high-power pulse transformers, power supplies, and related accessories for application to radar, missile guidance, communications, and tube development. Ask us for details or bring us your special problems.

If you think you would find designing equipment of this general type fascinating, maybe you should consider the possibility of coming to work at Levinthal. Get a resume shipped off to us today.



First multi-million watt klystrons were produced at **SPERRY**

Today—Sperry produces electronic tubes for every purpose—ranging in power from 20 milliwatts to over 5 megawatts.



STX-104 STX-105

NOW AVAILABLE New X-Band TWT Amplifiers from Sperry... for missile guidance, air navigation systems, and other CW applications... combining

Broadband response... high power... high gain... rugged long life construction

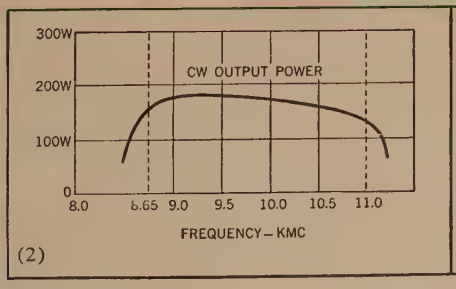
These two new Sperry Traveling Wave Tubes offer a unique *combination* of features which make them first choice for many applications in missile guidance, navigation and communications — whether airborne, ground or shipboard based. Both offer the fourfold advantages of high power, high gain, broadband response, and extra-rugged design for high altitude and severe environment performance. Minimum peak output power is 100 watts, with 150 watts averaged over the frequency ranges of the two tubes. The characteristics of the STX-105 curves shown below are duplicated in the corresponding frequency range of the STX-104. For complete data on the advantages of these new Sperry tubes for your current projects, write Sperry today.

SPECIFICATIONS

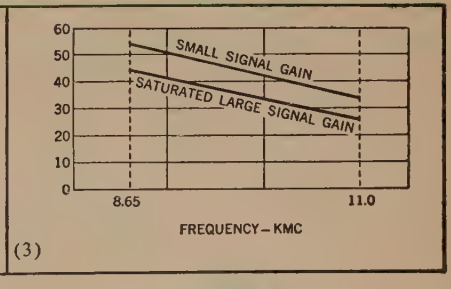
Frequency Ranges:	STX-104, 7.00-8.75 kmc; STX-105, 8.65-11.0 kmc
Small Signal Gain:	40 db nom
Output Power CW:	100 w min, 150 w min avg over frequency range
Gain at Rated Output Power:	30 db nom
Input Power at Rated Output Power:	630 mw max

MAXIMUM RATINGS: Beam Voltage, 8 kv; Body Current, 100 ma; Collector Voltage, 2660 v min (with respect to cathode); Operating Temp., 150°C

(1)



(2)



(3)

(1) Loaded waveguide structure and tough metal envelope of STX-104 and 105 provide high vibration and shock resistance, as substantiated by this and many other environmental tests conducted in Sperry labs. Quality components and integral input-output connections contribute to high performance reliability and long life. (2) Output Power vs. Frequency (3) Small and large Signal Gain vs. Frequency.

SPERRY

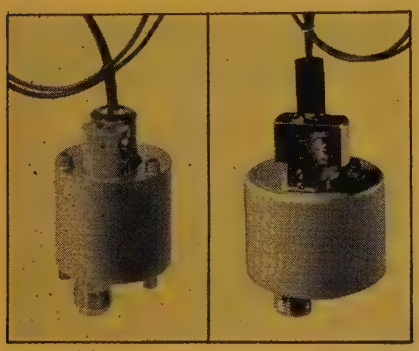
ELECTRONIC TUBE DIVISION, *SPERRY GYROSCOPE COMPANY, GREAT NECK, NEW YORK, DIVISION OF SPERRY RAND CORPORATION*
Address all inquiries *to Great Neck or Sperry offices in Brooklyn, Boston, Philadelphia, Los Angeles and Montreal. Export Dept., Great Neck, New York*

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 5

NEW RAYTHEON MICROWAVE TUBE DEVELOPMENTS

Miniature pulsed magnetrons for missile beacon applications are ruggedly constructed with integral magnets. The RK-7461 is tunable from 9,300 to 9,500 mc and has minimum peak power output of 60 watts. It is 1¼" in diameter and 2½" long, and weighs only 6 ounces.



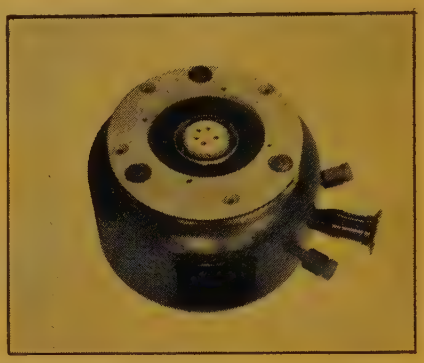
RK-7461 QK-735

The QK-735 is tunable from 5,400 to 5,900 mc with minimum peak power output of 400 watts. 1½" in diameter and 3¼" long, it weighs 8 ounces.

CIRCLE 40
Reader Service Card

* * *

Designed for electronic countermeasures and FM/CW operations, the QK-625 BWO provides a minimum CW power output of 180 watts and a nominal CW power output of 250 to 350 watts over the 2,500 to 3,000 mc band. The tube is voltage tunable over the entire range with tuning sensitivity of approximately 0.4 mc/volt. Liquid-cooled, the QK-625 BWO is equipped with an integral



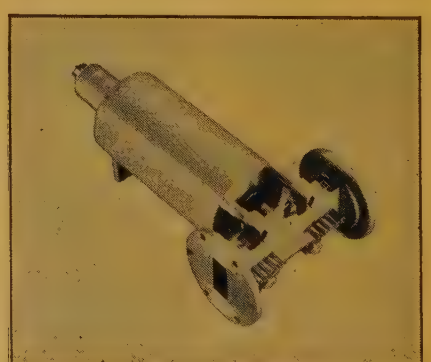
permanent magnet, and can be mounted in any position.

CIRCLE 41
Reader Service Card

* * *

Small-signal gain of up to 35 db in microwave relay links is achieved by means of a new compact traveling wave tube amplifier -- the QK-542. This permanent-magnet focused CW tube has nominal saturated power output of 5 watts over 5,900 to 7,400 mc. An integral UG 344/U waveguide-type flange is supplied as standard. With an optional coaxial output coupler the QK-542 covers 4,000 to 8,000 mc.

CIRCLE 42
Reader Service Card



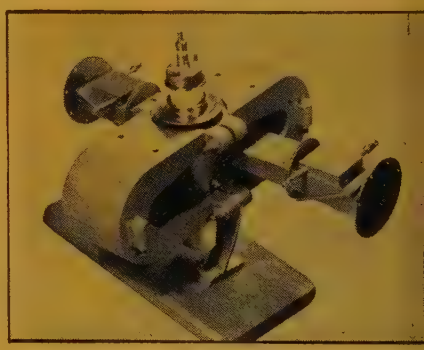
Raytheon at WESCON Booths 2131-2134

A Leader in Creative Microwave Technology

RAYTHEON

Ideal for linear accelerators and high-power radar systems. The QK-783 and QK-622 Amplitrons operate over the 2,700-2,900 mc and 2,900-3,100 mc bands, respectively, at a peak power of 3 megawatts and a typical efficiency of 75%. Because no heater is required, these tubes are capable of exceptionally long life. RF gain is 8 db under rated conditions, and as high as 12 db at lower peak power outputs. Phase pushing figure is less than 0.5 degrees for a 1 variation of anode current.

CIRCLE 43
Reader Service Card



* * *

Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

CIRCLE 44
Reader Service Card

BY DAVID H. SIMON

DR. SAMUEL SILVER

UNIVERSITY OF CALIFORNIA AT BERKELEY

High up in the hills of Berkeley, California, overlooking Berkeley, the University of California, and San Francisco we locate a large, comfortable looking home. We ring the bell; the door opens and a huge dog jumps forward as if to attack — but instead, greets us with a lick of the hand and a wag of his tail. Dr. Samuel Silver, unnoticed while we prepared to defend ourselves, now moves forward into the field of vision, warmly pumps our still-wet hand, and leads us up to his private study at the top of the house.

He disappears briefly. We look around the room and find signs not only of the devoted scientist but of a well-rounded man: a bookcase with the expected technical books, alongside a wide range of literary works — Thomas Mann and Proust, de Maupassant, Ogden Nash, French plays by Racine and Moliere; a music stand; a photographic tripod; a detective story in French, in the process of being read. (Dr. Silver, returning as we look through the detective story, explains that he's no French scholar but reads this sort of thing for diversion.) We settle down to draw from the modest Silver the details of his early life and his scientific work.

Samuel Silver was born in Philadelphia on February 25, 1915, to deeply religious Jewish parents. Along with his schooling at Philadelphia elementary schools and Central High School, he took formal religious schooling which continued through his second year of college.

Both at home and in his religious training, Silver was instilled with the traditional idea that the two most honorable professions were medicine and the rabbinate. Both seemed interesting and challenging, but as a high school senior he realized it was too early to decide between them. Since a college degree would be required in either case, he entered nearby Temple University as a pre-medical major.

From the beginning of his college studies Silver and many of his friends began to undergo what he describes as a philosophical revolution. This was caused less by the contradictions between science and belief in God than a growing feeling of conflict between religion and reality — the two just didn't seem to jibe any longer. Perhaps, as with many college students, Silver was questioning for the first time many of the precepts he had been taught earlier. In any case, where religion seemed unable to provide answers to his searching questions, science did. This led to greater and greater interest in scientific studies; and although Silver was now intent on a medical career, he switched his major to physics, much to the perplexity of the college authorities. (The reason was that he planned to combine medicine and scientific investigations by being a medical researcher.)

The decision was a wise one. Physics seemed to be just what Silver was suited for, and he threw himself into his studies with an ardor. So outstanding was his work that he was permitted to teach basic physics courses while still an undergraduate.

(In some of the laboratory sessions was Marjorie Euster, a young co-ed who wasn't even taking the course. Ostensibly assisting a friend, she was actually there to meet the brilliant-but-exacting instructor she'd heard so much about. The co-ed didn't learn much about physics, but the instructor learned much about the ways and wiles of womankind: he soon found himself wooing and later married her.)

In 1935 Silver graduated at the top of his class, receiving a B.A. in Physics and the Pyramid Scholarship Key. Interest in the work he had been doing, insufficient funds, and the urging of his professors and associates convinced him to put aside plans for medical studies and continue as a Teaching Fellow and graduate student. For two years he did research on x-ray analysis of the structure of liquids and crystals, and earned an M.A. in Physics in 1937.

Now a confirmed physicist, Silver entered the Massachusetts Institute of Technology for theoretical studies on the vibrational states of polyatomic molecules. Financial backing came first in the form of a teaching fellowship, and later, an MIT Doctoral Research Fellowship. His work at MIT culminated in a Ph.D. in 1940. He spent the following year in continuation of his investigations on the

(*Continued on page* 21)

Power your TWTs and BWOs with the ALFRED 250

ALFRED's versatile Model 250 will operate more low-powered and low noise TW tubes than any other commercially available power supply. It operates most medium-powered traveling wave tubes as well. High regulation, low ripple and low drift make the Model 250 an ideal standard for testing and evaluating tubes, backward wave oscillators and carcinatrons.

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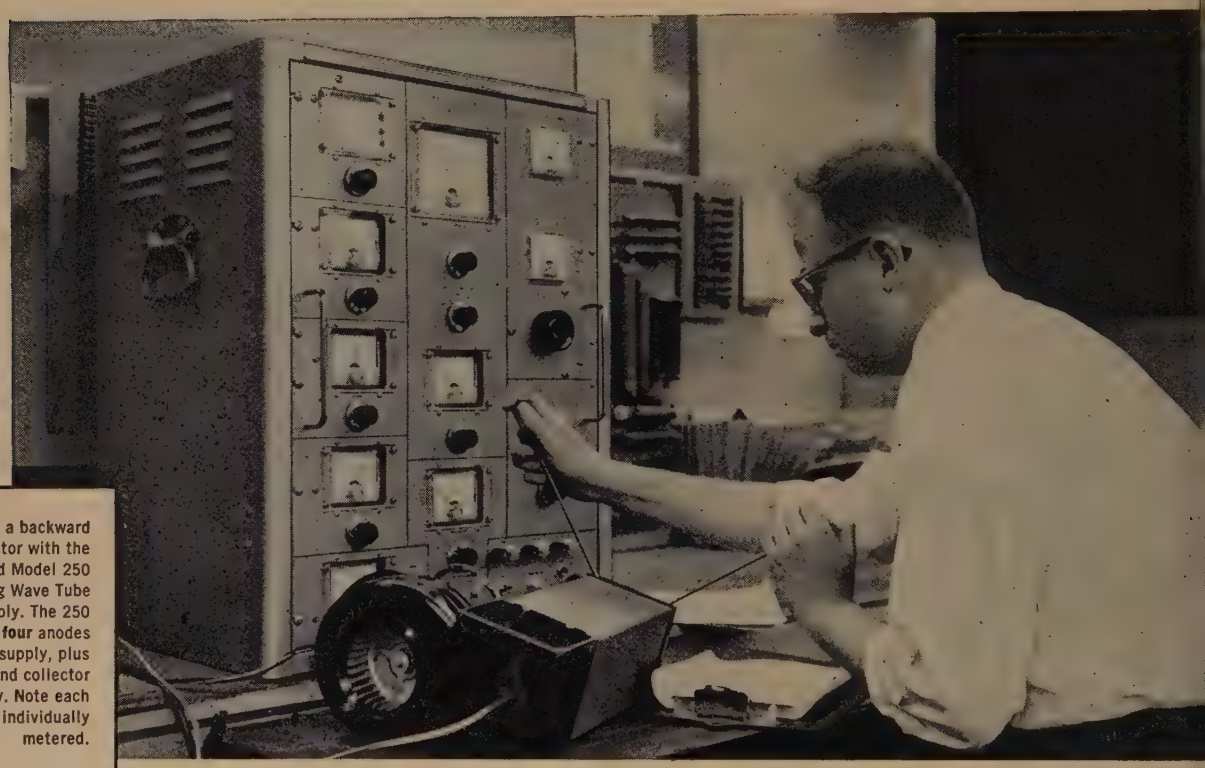

Aligning a backward wave oscillator with the Alfred Model 250 Traveling Wave Tube Power Supply. The 250 features four anodes and grid supply, plus helix and collector supply. Note each supply is individually metered.

TUBE EVALUATION

Send us your tube type specifications. Alfred Electronics will be happy to evaluate them and advise whether the Model 250 will operate your tube.

Alfred Electronics offers the industry's most complete line of packaged traveling wave tube amplifiers. Write for new short form catalog.

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BRIEF SPECIFICATIONS

HELIX SUPPLY	
Voltage	90 to 3500 v, range switch and 10 turn vernier
Current	0 to 5 ma to helix 0 to 60 ma to collector
External Modulation	Direct or capacitively coupled
PROTECTION	Overcurrent relay shuts off all high voltage supplies
COLLECTOR SUPPLY	
Voltage	0, +150, +250 v, relative to helix
Current	0 to 60 ma
GRID SUPPLY (relative to cathode)	
Voltage	0 to −150 v
Current	.1 ma average
External Modulation	Direct or capacitively coupled

ANODE SUPPLIES (relative to cathode)		
	#1	#2
Voltage	0 to + 450 v	0 to + 300 v
Current	0 to 20 ma	0 to 1 ma
	#3	#4
Voltage	0 to +750 v	0 to 2500 v
Current	0 to 1 ma	0 to 1 ma
HEATER SUPPLY		
Voltage	0 to 10 v ac	
Power	20 va maximum	
SOLENOID SUPPLY		
Voltage	0 to 100 v	
Current	0 to 7 amperes	
BLOWER SUPPLY		
Voltage	115 v ac or 28 v dc	
Current	0 to 1 ampere ac or dc	
PRICE	$1990 F.O.B. Palo Alto	

nfra-red spectra of solids and on the vibration-rotation nergies of polyatomic molecules as a research assistant n physics at Ohio State University.

As the MIT Radiation Laboratory was being formed, nembers of the staff who were familiar with Silver's work ontacted him to see if he would be interested in returning. He was, but since he had just signed a contract with the Jniversity of Oklahoma it was not possible. At Oklahoma e served first as an instructor in physics and then an ssistant professor, while furthering his earlier research tudies.

We are interrupted by a knock on the door, and Mrs. ilver enters with coffee and brownies the professor had equested during his disappearance earlier. From her we earn of their 15-year-old daughter, Deborah and 18-year-ld son, Daniel. The tripod, we learn, is part of a sizable ollection of photographic equipment — a hobby her hus-and started in high school. Dr. Silver interjects that al-hough he's still interested in photography, it's the prob-em of balanced composition that he now finds challenging, o he seldom prints the film.

The music stand represents a brief fling with the violin. Like a father fascinated with the Christmas presents in-ended for his offspring, Silver bought the violin for his on, ended by taking lessons on it himself.

Coffee over and our quizzing of Mrs. Silver completed, ve return to Dr. Silver's career.

In early 1943, his obligations to the University of Okla-oma completed, he made himself available to the Rad Lab. Although he would have preferred to continue work n molecular physics the Lab badly needed electrical en-gineers, and Silver joined the antenna group. The projects vhich received the bulk of his attention included the ap-plication of electromagnetic theory to microwave optical ystems, physical optics, pattern synthesis, horns, and natching networks. One of his major contributions was he development of a special bombing antenna. Previous lesign had made available a cylindrical reflector using a ine source, but this application required a point source orn feed and a fan beam. Silver achieved this by devising doubly-curved reflector, making use of his previous knowledge of optics principles.

At the termination of the Radiation Lab, he acted as editor of Volume 12 of the Radiation Lab Series, on Micro-wave Antenna Theory and Design, and authored a number of chapters in the volume.

Having become something of an expert on antennas, Silver joined the newly formed Antenna Research Branch of the Naval Research Laboratory under the direction of Dr. L. C. Van Atta, where he headed up the Basic Research Section. His energy was devoted primarily to fundamental theoretical and experimental problems of applied electro-magnetic theory, scattering, and diffraction. During this period he also served as a Navy representative to the Panel on Radiating Systems of the Research and Development Board, and he had the major responsibility for formulating the long range research program in the field of radiating systems.

In September 1947 Silver accepted appointment as Associate Professor of Electrical Engineering at the Uni-versity of California in Berkeley where he instituted a fundamental research program on microwave antennas, scattering and diffraction, as well as graduate studies in applied electromagnetic and antenna theory. He was re-

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that can more than triple the range of existing microwave beacons and provide countermeasure systems with tangential sensitivities as high as —65 dbm. Available with standard brass connectors and bodies . . . or aluminum for LIGHTWEIGHT applications. (available with type N, TNC, Miniature, and BNC connectors).

Mounts available from 50 Mc/s to 12 KMC in continuous or octave bands in coaxial configuration. Higher frequencies in waveguide.

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Transistorized or hard-tube crystal video receiver amplifiers designed with high input impedance to prevent crystal detector loading. Other features include . . . low equivalent noise, high gain, crystal bias circuits, small size and LIGHT WEIGHT. Several "standard" models available or units built to your specifications.

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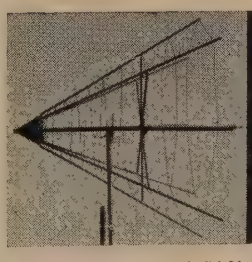
BROADBAND ANTENNAS



AEL's Broadband circularly polarized conical helix antenna, matched over greater than 10 to 1 frequency bands, is ideally suited for countermeasures and telemetering applications. The teardrop pattern, of essentially constant beamwidth, provides a unique broadband, circularly polarized feed antenna for parabolic reflectors.

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AEL has built VHF-TV Slotted Cylinders, Air Inflated Monopoles, Discones, Horns, Airborne Blade and many other antennas. For solutions to your antenna problems contact AEL for the services of a highly skilled team of antenna design engineers working in our modern high frequency and microwave laboratories at AEL's 50 acre tract in Colmar Penna.

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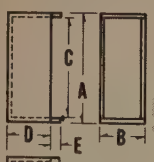
BROAD-BAND CAVITIES for non-contacting WAVEGUIDE SHORTS

IN STOCK for IMMEDIATE DELIVERY



For all waveguide sizes from S- to K-band, these cast beryllium-copper broad-band cavities provide a quarter guide wavelength from the finish face to the cavity opening. Units are supplied slightly oversize so you can finish them to your precise requirements.

Cavities can also be furnished in cast aluminum, or can be *fabricated* in larger sizes, on special order.

THESE CAVITIES ARE IN STOCK FOR IMMEDIATE SHIPMENT

Model	Frequency Range KMC	Dimensions					
		A	B	C	D	E	Price
207-S	2.60-3.95	2.850	1.350	2.705	1.215	.250	$15.00
207-C	3.95-5.85	1.880	.880	1.755	.820	.187	9.00
207-XC	5.85-8.20	1.380	.630	1.310	.555	.160	6.00
207-BL	7.00-10.0	1.130	.507	1.060	.460	.125	4.00
207-X	8.20-12.4	.906	.404	.830	.387	.125	3.50
207-KU	12.4-18.0	.625	.314	.550	.278	.125	3.00
207-K	18.0-26.0	.425	.173	.350	.184	.105	2.50

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CIRCLE READER SERVICE CARD 14

warded for his success on these pr grams by promotion to full professo and in 1952, as a result of the develo ments in both the graduate and r search studies, he received the design tion "Professor of Engineerin Science."

The recipient of a Guggenhei Fellowship in 1953, Silver spent year of study and research at sever European centers, primarily at th Laboratory for Telephony and Tel graphy of the Royal Technical Unive sity and the Boht Institute in Cope hagen, and in the Radiophysics Div sion of the Cavendish Laboratory Cambridge University.

After returning to the Universi of California, Silver had added to h previous jobs the post of Director the Electronics Research Laboratory the Department of Electrical Enginee ing and Institute of Engineering R search.

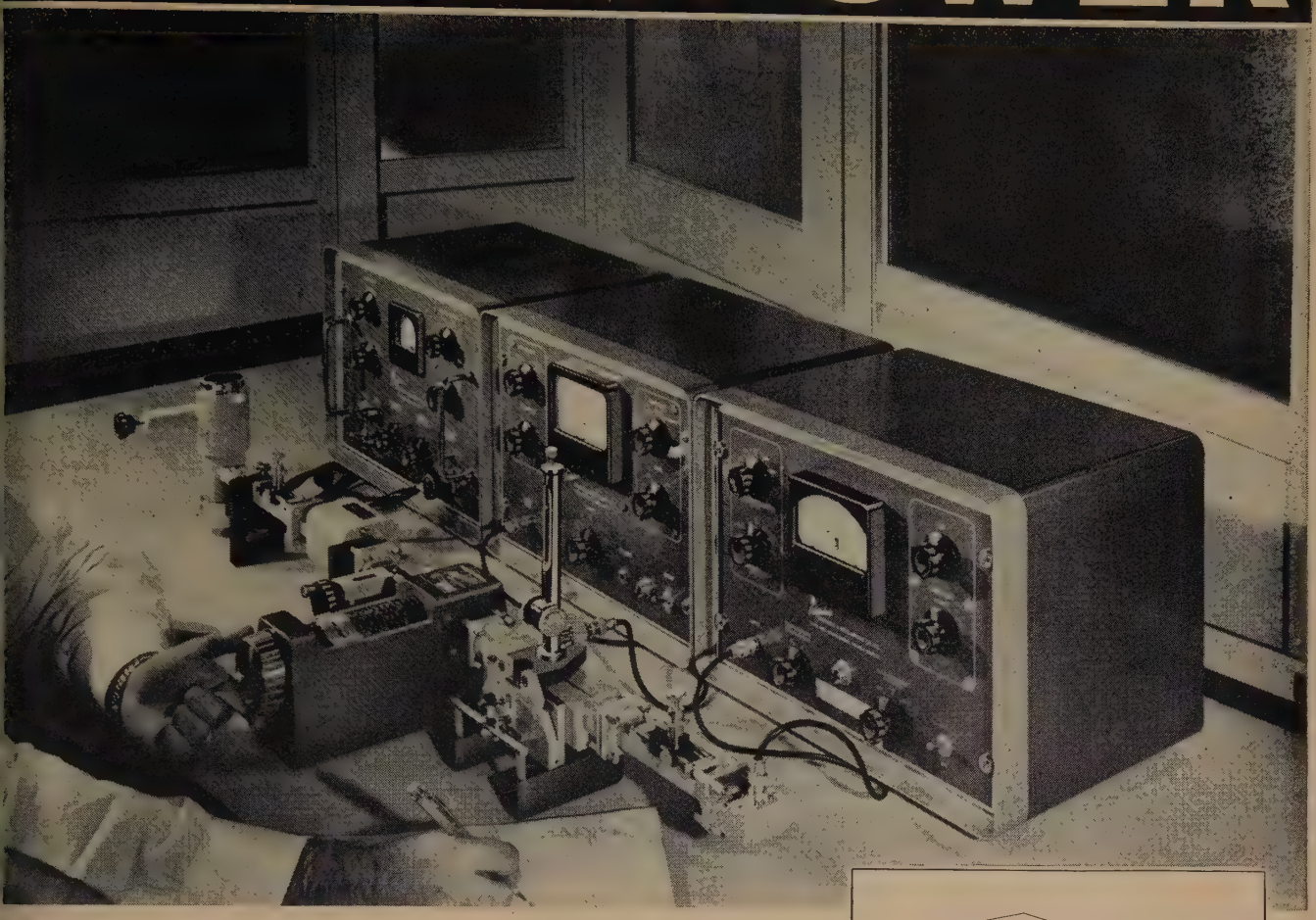
Professor Silver's teaching time now divided between electrical e gineering and physics; his research centered on radiating systems, radi astronomy, and upper atmospher work.

Silver is also very active in affairs technical societies. He is a Fello of the IRE and of the American Phys cal Society. He was co-chairman of th Technical Program Committee of th 1955 WESCON and for the past thre years has been a Director of the Sa Francisco section of the IRE. Othe IRE activities include membership i the Professional Group on Antenn and Propagation and the Professiona Group on Microwave Theory an Techniques. In addition, he is a mem ber of Sigma Xi, the New Yor Academy of Sciences, Eta Kappa Nu and Tau Beta Pi.

For a number of years Silver ha also been an active member of th International Scientific Radio Union He has attended the General Assem blies of the Union since 1950, and i 1958 was elected Secretary of th U.S.A. National Committee.

All of this in addition to his teach ing and research activities would see to require more than 24 hours ever day, but somehow Silver has als managed to squeeze in time as special consultant to the Office o Naval Research and the Weapon Systems Laboratory of the Air For and presently serves as consultant t several electronic companies.

HOW TO MEASURE POWER



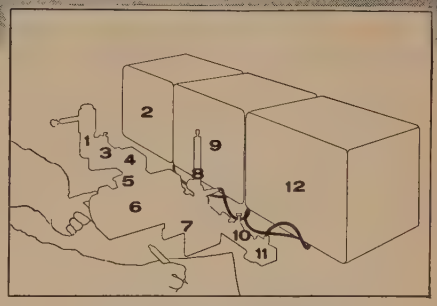
This microwave bench set-up is for the measurement of power by the Self-Balancing Bolometer Bridge method. Other systems, including PRD's more accurate Calorimetric Instrumentation could have been shown, but the Bridge represents the most universally used technique.

The operating procedure is quite simple. First adjust the PRD 650-B Universal Power Bridge for the thermistor or bolometer available. Next tune and match the transmission line for a minimum VSWR indicated on the PRD 277-A Standing Wave Amplifier. Then record the reading of the PRD 650-B Self-Balancing Bridge (directly in milliwatts) and you're ready for your next microwave measurement.

Easy, isn't it? Even more important it's accurate. The PRD 650-B Bridge has guaranteed accuracy of ±5% full scale. The use of the PRD 303-A Slide Screw Tuner eliminates the slightest mismatch of the 643 Thermistor Mount. The importance of fine matching can best be shown by example: a mismatch VSWR of only 1.2 would result in a power error of 1%.

The precision and ease of operation of all the products shown in this example are typical of each of over 300 microwave test instruments currently produced by PRD, the company that's FIRST IN MICROWAVES... our cable address is MICROWAVE, New York, U.S.A.

For technical details and specifications covering products shown write:



TEST INSTRUMENTS USED IN THIS X-BAND POWER BENCH

1—703 Shielded Tube Mount, catalog page F-8
2—809 Klystron Power Supply, catalog page F-10
3—303-A Slide Screw Tuner, catalog page B-14
4—1203 Isolator, catalog page A-21
5—159-A Level Set Attenuator, catalog page A-17
6—535 Frequency Meter, catalog page D-12
7—203-D Slotted Section, catalog page B-11
8—250-A Broadband Probe, catalog page B-12
9—277-A Standing Wave Amplifier, catalog page E-7
10—303-A Slide Screw Tuner, catalog page B-14
11—643 Broadband Thermistor Mount, catalog page E-9
12—650-B Universal Power Bridge, catalog page E-13

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Special problems in attenuation and other related measurements? Contact our Applications Engineering Department.

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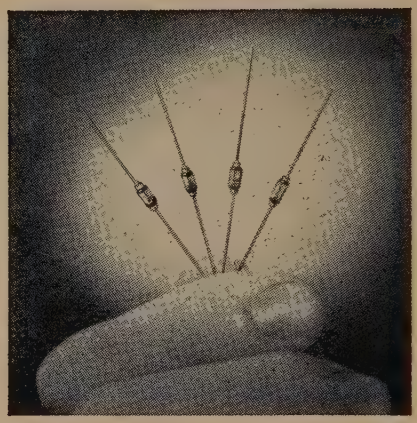
CIRCLE READER SERVICE CARD 15

Microwave Component News from SYLVANIA

NEW Sylvania Micro-Min Diodes

Sylvania opens the way to advanced miniaturization concepts in microwave and radar design with new smaller Silicon Microwave Diodes



Major step in the trend to ever smaller radar and microwave equipment to meet today's military and commercial demands is represented by Sylvania's new line of subminiature Micro-Min diodes. The new diodes meet the electrical performance of their larger counterparts and are equivalent in ruggedness and reliability. They combine in one unit Sylvania's unmatched experience in diode packaging and proven technical excellence in microwave diode design.

The subminiature metal-to-glass package opens the way to new possibilities in strip-line and slab-line transmission designs. Included among the new types are Detector Diodes ranging in frequencies from 100 mc to 9,000 mc and Mixer Diodes in frequencies from 3,000 mc to 9,000 mc. Contact your Sylvania representative for full information on the new subminiature microwave diodes—or write Sylvania directly.

NEW SYLVANIA MICRO-MIN DIODES

IN830 (D 4050)—UHF Detector	IN832 (D 4065)—X Band Mixer
IN831 (D 4064)—S Band Mixer	IN833 (D 4063)—X Band Video Detector

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SYLVANIA ELECTRIC PRODUCTS INC.
Semiconductor Division
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CIRCLE READER SERVICE CARD 16

INDUSTRY NOTES

(*Continued from page* 15)

Strum was vice-president for engineer with Ewen Knight Corp., Needham, M for three years, responsible for develop advances in radar receivers and radio tronomy techniques, before joining Gra in 1958. Previously he spent eight y with the Airborne Instruments Labora in high-performance receiver developm He also served in the Navy during W War II.

He received his B.E.E. from North C lina State College and his M.S. in electr engineering from Stanford Univers Strum is a senior member of the Insti of Radio Engineers and a member of Beta Pi, Sigma Xi and Eta Kappa Nu. has written numerous papers on rece design and radio astronomy.

• • •

MID-AMERICA ELECTRONICS CONFERENCE

The eleventh annual Mid-America E tronics Conference (MAECON-1959) be held in Kansas City, Missouri, on vember 3, 4, and 5.

Forty-five technical papers will be sented in 15 sessions. Some sessions wil conducted by The American Institute Electrical Engineers (AIEE) and American Rocket Society (ARS) on cialty subjects that should be very in esting.

Dr. Ernest Weber, President of the and President of the Polytechnic Institute Brooklyn, will speak at the opening sess (Tuesday, Nov. 3) on "The Radio E neer of the Future."

The technical sessions and the exhi will be held in the spacious Munici Auditorium located in the heart of do town Kansas City, one block from conference headquarters, Hotel Muehleba

The exhibit area of more than 100 boo will be open during the entire confere

Additional detailed information may obtained from: Ira J. Jones, Bendix A tion Corporation, P.O. Box 1159, Kan City 41, Missouri.

• • •

UNION ELECTRIC, ST. LOUIS UTILITY, EXPANDS MICROWAV SYSTEM

One of the nation's largest utility u of microwave communication, Un Electric Company, is installing Gen Electric 2 KMC equipment for a 170-mile route running from the firm's Louis headquarters to the company's V sub-station near Fort Madison, Iowa.

The installation represents a sizea addition to Union Electric's existing co munications system. It will be used voice functions, telemetering, supervis control and remote control of existing V base stations.

General Electric's Communication P ucts Department, Lynchburg, Va., supply seven microwave stations for new link, which will serve as a relay

communications facilities at St. Louis and Louisiana, Mo., and Keokuk, Ia.

Union Electric, one of the country's microwave pioneers, presently has a large microwave system covering the territory west of St. Louis. A shorter one handles communication to the east of its headquarters.

The low-maintenance 2 KMC equipment to be used in the northern link is the first General Electric microwave to be installed by the mid-west utility.

• • •

RADAR TUBE CONTRACT TO DUMONT

A contract in excess of $70,000 for 3,200 radar indicator cathode-ray tubes has been received by the Electronic Tube Division of Allen B. Du Mont Laboratories, Inc. The tubes are Type 12DP7A, and the contract was placed by the Dayton Air Force Depot, Dayton, Ohio, through the Newark Air Procurement District.

• • •

BAILEY JOINS INTEC

Intercontinental Electronics Corporation (INTEC), Mineola, New York, announced that Mr. Llewellyn H. Bailey has joined the staff as Contract Coordinator. In this capacity, Mr. Bailey will be responsible for all areas connected with company operations.

Formerly with Rocke International, Mr. Bailey's background includes technical and technical sales experience in the systems field. During his twenty year career, he has served in important positions in the Communications, Television, Components and Government Contracts Business.

INTEC, a systems manufacturer for the aircraft, power instrumentation and telecommunications industries is jointly owned by Airborne Instruments Laboratory, a division of Cutler Hammer, Compagnie de Telegraphie Sans Fils (CSF), American Research and Development Corporation, the Morgan Guaranty Trust Company and the Banque de Paris.

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MICROWAVE Kearfott DIVISION

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LOW POWER
BROAD and NARROW BANDS
LOW INSERTION LOSS
HIGH ISOLATION
SMALL SIZE
LIGHTWEIGHT

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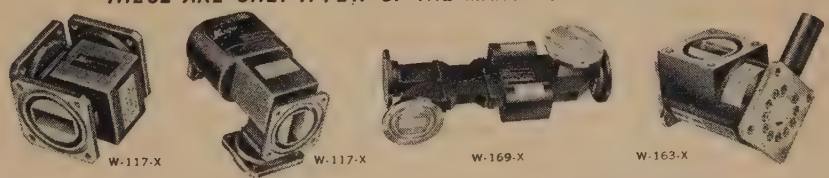
Kearfott Ferrite Circulators—a **complete line** especially designed to meet the growing need for reliability, precision and performance in the space age. In the broad range of sizes and types, there is a circulator to fit **your exact requirement.** Our engineers will be pleased to offer application assistance.

Engineers: Kearfott offers challenging opportunities in advanced component and system developments.

	TYPICAL SPECIFICATIONS			
MODEL	FREQ. RANGE	ISOLATION	INSERTION LOSS	V.S.W.R.
W-169-7B-5	8500-9600 MC	25 DB Min.	0.3 DB Max.	1.10 Max.
W-163-1C-1	9.2-9.4 KMC	20 DB Min.	0.5 DB Max.	1.25 Max.
W-117-2A-1	9200-9400 MC	18 DB Min.	0.3 DB Max.	1.30 Max.
W-269-2A-1	5.975-6.425 KMC	20 DB Min.	0.7 DB Max.	1.25 Max.
W-569-1B-2	16.0-17.0 KMC	I-III 30 DB Min. II-I 20 DB Min.	0.5 DB Max.	1.20 Max.

THESE ARE ONLY A FEW OF THE MANY AVAILABLE MODELS



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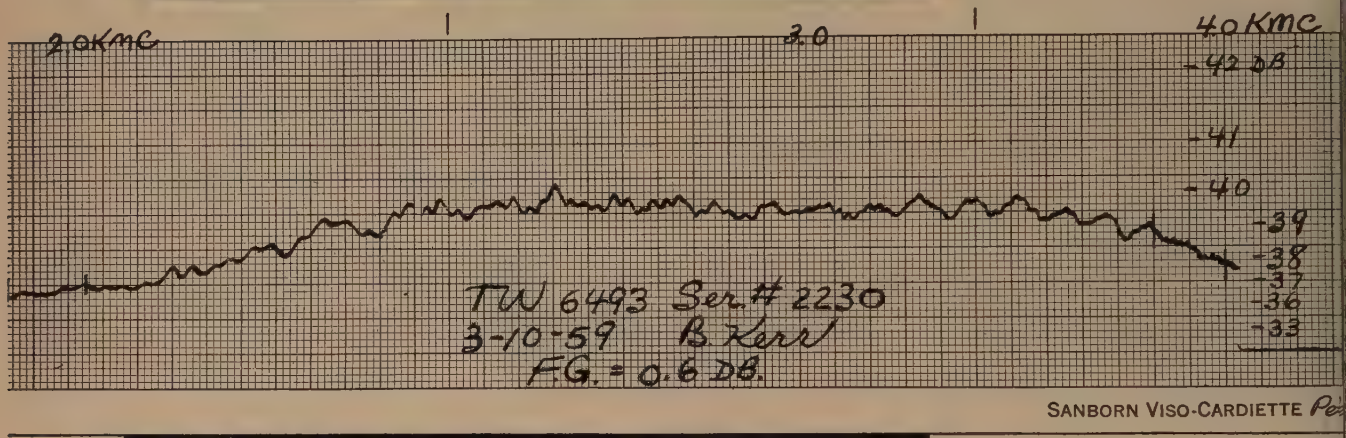
CIRCLE READER SERVICE CARD 17

Microwave Component News from SYLVANIA

Now available—a wide range of traveling wave tubes



Actual strip chart recording of test on a production tube shows the uniform gain characteristics of this Sylvania tube over the 2.0 KMC to 4.0 KMC spectrum

ONLY SYLVANIA CAN OFFER YOU

AVAILABILITY—now in production, 16 types of traveling wave tubes covering the microwave spectrum from 1 to 11 kmc, and milliwatts to kilowatts. Backward wave oscillators are also available. Modifications and new designs for your special requirements are part of Sylvania's service.

HIGHEST GAIN—Sylvania's traveling wave tubes deliver 2 to 5 times the gain of competitive types. For example, TW-4002 delivers a minimum gain of 37 db over its full 2 to 4 kmc band.

GUARANTEED UNIFORMITY— Sylvania guarantees gain variations one-half those of other tubes; i.e. 2 to 3 db narrower limits. Other test limits are correspondingly more rigid.

PROVEN RUGGED DEPENDABILITY—Sylvania traveling wave tubes have proved their performance by meeting tough military standards and by being specified and used in modern supersonic aircraft.

For more information
write your nearest Sylvania tube sales office or
Sylvania Electric Products Inc.,
Special Tube Operations,
500 Evelyn Ave., Mountain View, Calif.

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GENERAL SYSTEM

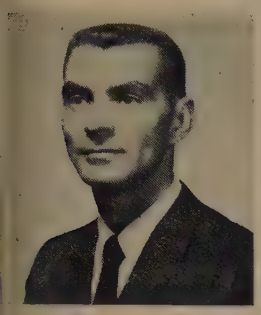
DAVID I. BREITZER received the B.E.E. and M.E.E. degrees from The College of the City of New York in 1938.

In 1939, he was with the U.S. Navy Department as a junior naval architect. From 1939 to 1941, he worked with the New York City Board of Transportation as a junior electrical engineer. From 1941 to 1945 he worked on the Panama Canal as an electrical engineer. During 1946 and 1947, he worked for the Celanese Corporation of America as an electrical engineer.

In 1947, Mr. Breitzer joined AIL, and has been engaged principally in mathematical analysis of systems and problems connected with radar and guided missiles. This work has included the evaluation of signal-to-noise ratios, the solution of electromagnetic field boundary value problems, the analysis of transients in lumped and distributed circuits, network analysis, and the solution of varied types of stochastic problems.

In the field of radiation detection, Mr. Breitzer has analyzed the operating characteristics of a microwave ionization chamber, and has contributed to the solution of several low-noise circuit problems. Most recently, Mr. Breitzer has been engaged in theoretical studies relating to the use of semiconductor diodes as low-noise amplifiers and harmonic generators.

Mr. Breitzer is a member of Tau Beta Pi.



EDWARD S. HENSPERGER was born in New Brunswick, N.J. on December 12, 1925. After serving three and a half years in the Marine Corps in the South and Central Pacific during World War II, he entered Rutgers University in 1948, and received the degree of B.S. in electrical engineering in 1952.

In June, 1952, Mr. Hensperger joined Airtron, Inc., Linden, N.J. where he became engaged in the design and development of microwave components. In 1955, he left Airtron to become a senior design engineer at Stavid Engineering, Inc., Plainfield, N.J.

In 1956, Mr. Hensperger returned to Airtron as Section Engineer in charge of the advanced microwave design group. In this position, he took charge of the development of various ridge waveguide components, microwave filters, and other waveguide structures and systems.

In April, 1959, Mr. Hensperger joined Waveline, Inc., Caldwell, N.J., manufacturers of microwave test equipment, where he presently holds the position of Chief Engineer.

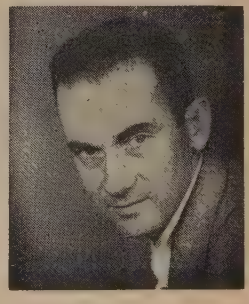
NICHOLAS V. KARAS was born in Lowell, Massachusetts in 1925. After a term in the military service he entered the University of Massachusetts where he received a B.S. degree in Mathematics. From 1952 to 1954 he was employed by the Air Force in Washington, D.C. While there, he was enrolled at George Washington University. In 1954 he joined the Electromagnetic Radiation Laboratory of the Air Force Cambridge Research Center. His main interest has been in flush mounted scanning antennas for missiles, and in this connection has performed investigations on trough guides, sandwich wire printed circuit arrays, and ridge waveguide antennas. He is a member of the IRE.

WALTER ROTMAN was born in St. Louis, Missouri on August 24, 1922. He received the B.S. and M.S. degrees in Electrical Engineering from Massachusetts Institute of Technology in 1947 and 1948 respectively. From 1942 to 1945 he served in the U.S. Army Air Force, working on radar equipment. During his student career he worked as a research assistant in the Research Laboratory of Electronics, MIT, on high-powered magnetron problems.

In 1948, Mr. Rotman joined the Electromagnetic Radiation Laboratory of the Air Force Cambridge Research Center, where he is chief of the Missile Antenna Section. His fields of interest include microwave optical systems, missile antennas, and the interaction of microwave with plasma.

He is a member of RESA, Sigma Xi, and the IRE.

EUGENE W. SARD was born in Brooklyn, New York in 1923. He received the B.S. and M.S. degrees in electrical engineering from the Massachusetts Institute of Technology in 1944 and 1948 respectively. From 1944 to 1946, he served in the USNR as a radar officer. From 1946 to 1948, he was a research assistant in the Center of Analysis and the Servomechanisms Laboratory at MIT, working on digital computers.



Mr. Sard joined Airborne Instruments Laboratory in 1948 working at first in the Radar Department on single-channel and multiplex Track-While-Scan Systems. Presently he is a Consultant in the Applied Electronics Department, and for the past three years has been working on the application of semiconductor diodes to various fields including low-noise amplification, harmonic and subharmonic generation, and fast switching.

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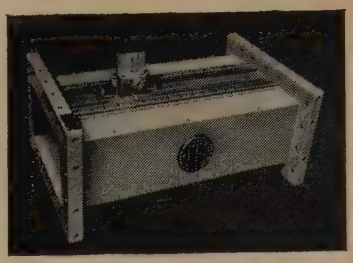

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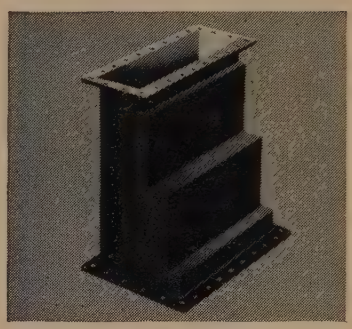

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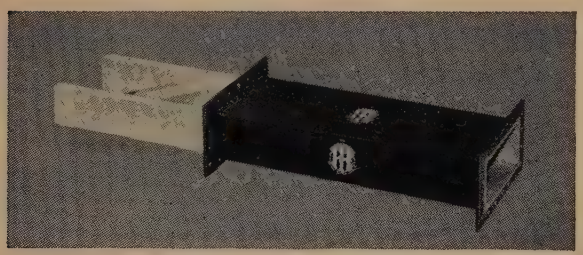

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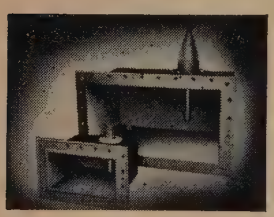

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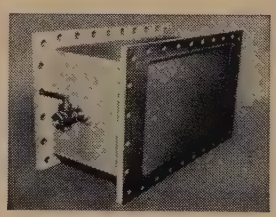

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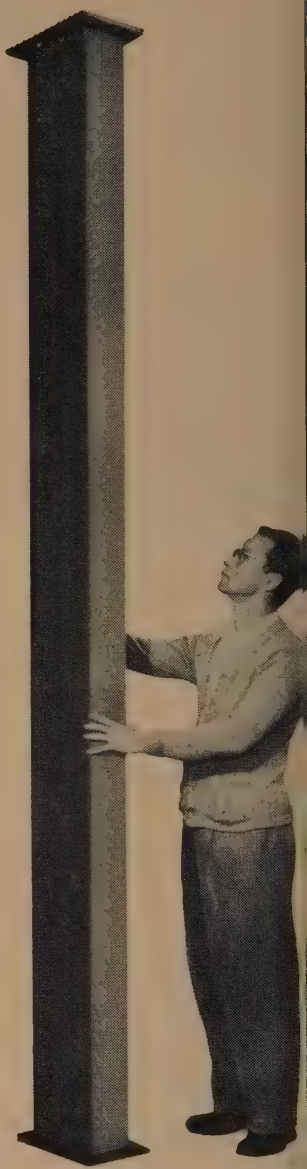
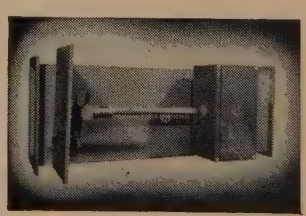
Bends



Straight sections

Slotted lines



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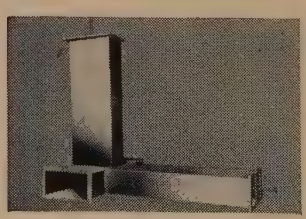

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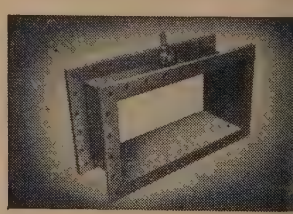

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ABSTRACT

A new microwave line source configuration consists basically of three continuous coplanar conductors. The two outer conductors, parallel to each other, are at ground potential; the excited center conductor is bent into sinusoidal form, with a period (for broadside radiation) equal to the wavelength. The polarization is transverse to the length of the array. Modifications of the basic design include a printed-circuit (metal on dielectric) two-dimensional array fed by a corporate structure feed.

Design data, including attenuation and phase characteristics, are given for a flat-plate S-band model. An array to fit a cylindrical surface is discussed.

These structures are mechanically simple, have good impedance characteristics, and allow good control over aperture illumination.

THE SANDWICH WIRE ANTENNA

WALTER ROTMAN and NICHOLAS KARAS

Air Force Cambridge Research Center
Bedford, Massachusetts

1. Introduction

An important objective in radar engineering is the reduction of size, weight, and complexity of antennas having large radiating apertures. The successful results obtained with printed circuit techniques in low-frequency and microwave[1] strip circuits have prompted attempts to extend such methods to microwave antennas.[2, 3] This paper describes a new class of radiators called "sandwich wire" antennas.[4] Adaptable to printed-circuit processes, these microwave line sources can be constructed as flat or curved plate structures with linear polarization for either pencil beam or shaped radiation patterns.

The sandwich-wire antenna can be analyzed from the characteristics of strip transmission lines. A flat strip transmission line (Figure 1*a*) consists of three parallel elements: one center strip conductor and two outer plates, with the field concentrated in the region of the center strip. So long as the three elements remain parallel, displacement of the strip from its center position has little effect on the transmission line mode.

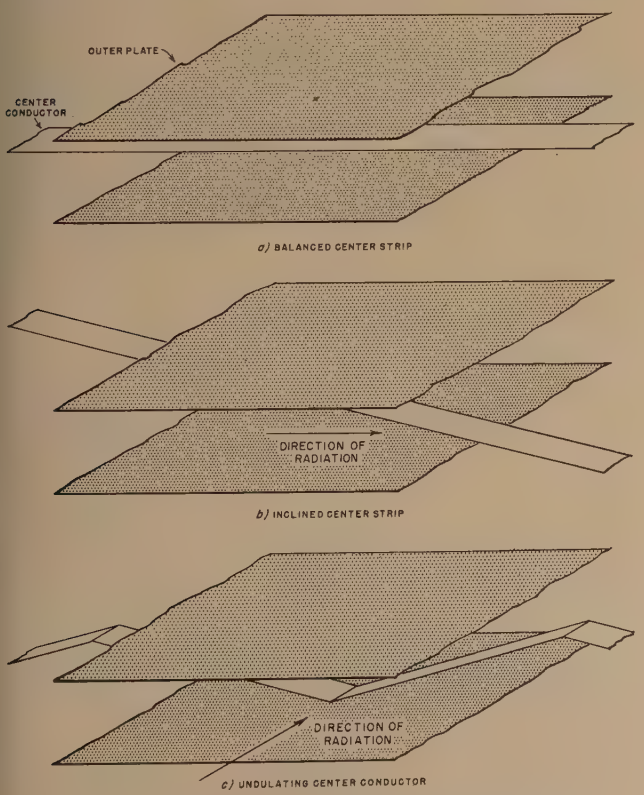

Figure 1 — Radiation from strip transmission line.

Strip lines are normally nonradiating but can be made to radiate by simple changes. If the center conductor is inclined (Figure 1*b*) so that it is no longer parallel to the outer plates, an unbalanced condition results, some energy being converted from the guided stripline mode into a TEM mode between parallel plates. Since its excitation is progressively phased, the TEM mode is not constrained but propagates unguided in the general direction of the length of the stripline.

For the TEM waves to propagate broadside to the center conductor of the stripline, the phase must reverse periodically between successive radiating points on the strip. Periodic phase reversal can be obtained by bending the center conductor so that the direction of its slope is regularly reversed (Figure 1*c*). If the periodicity of the center conductor is one wavelength, the regions of maximum radiation are spaced every half wavelength along the line. Phase reversal introduced between successive points a half wavelength apart brings all the radiating regions into phase, and the stripline radiates into the parallel plates with a broadside pattern.

If the center strip and outer plates of the stripline are compressed to one-dimensional conductors, the configuration assumes the shape of the sandwich-wire antenna (Figure 2). Its structure consists of three continuous coplanar conductors. The center one, connected to the inner conductor of an unbalanced coaxial or strip transmission line feed, undulates periodically; the two straight outer wires are grounded to the external shield of the input. This type of antenna is essentially a traveling-wave array that acts like a radiating transmission line. It cannot radiate any longitudinal component of the electric field (for spacings of less than a wavelength between outer conductors) since radiation from the longitudinal currents on the center conductor is in effect canceled by the equal and opposite currents on the outer conductors. An uncanceled transverse component of current does exist, however, owing to the undulation of the center wire, and is free to contribute to the radiated field.

The center conductor of the sandwich wire antenna can undulate in any simple periodic form. Besides the trapezoidal (Figure 2), variations include sinusoidal, triangular, and extended length configurations. In all these cases the intensity of radiation can be controlled by varying the degree of undulation in the center conductor.

The sinusoidal form was selected for experimental study

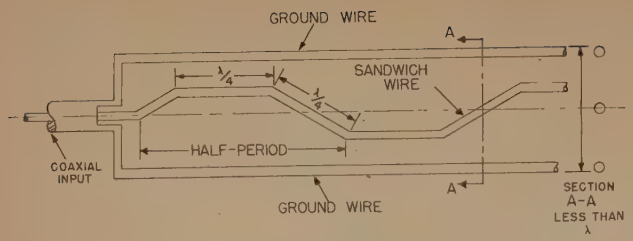

Figure 2 — The sandwich-wire antenna: basic configuration for broadside radiation.

because the discontinuities caused by the bends and the changes in characteristic impedance are small. Even in this type, when the antenna is adjusted for broadside radiation the cumulative reflections add up in phase to a fairly high input voltage standing wave ratio. These reflections result from the periodic changes in characteristic impedance caused by the undulations. At other frequencies for which the beam is not broadside, the reflections are not in phase and the input VSWR is low. This type of behavior indicates that broadband impedance-matching can be achieved through compensating for reflections by such means as capacitive tabs spaced at half-wavelength intervals along the array. Since these additional reflections cannot add up in phase for any frequency other than the one that gives broadside radiation, the array is then automatically compensated in impedance for all frequencies of interest.

The radiation pattern in the longitudinal plane depends on the termination and geometric configuration of the array. In general, the currents on the center wire can be resolved into incident and reflected traveling waves. Each wave produces a single main beam in space. The two beams make equal and opposite angles with the normal to the array. The pattern of the antenna is the vector sum of these two beams, whose intensities are proportional to the relative magnitudes of the two waves on the line. The termination is usually resistive and matched to the characteristic impedance of the line, in which case only a single traveling wave and single radiated beam exist.

The angle at which the beam radiates depends on the relative phasing of the radiating regions, and this is a function of the spatial periodicity of the center wire. In the previously mentioned special case for which the period is one wavelength, the radiation pattern is exactly broadside to the array. In the case of a periodicity that is not one wavelength, the beam emerges at some angle that can readily be computed from elementary considerations and we then make the assumption (verified by experiment) that the wave travels along the center wire with a velocity close to that of light.

In Figure 3 the phase difference ϕ between points spatially a half period apart on the center wire is given by

$$\phi = \frac{\pi L}{\lambda_w}.$$

With these points considered as discrete radiators, the peaks of radiation occurs at angles given by

$$\frac{\pi L}{\lambda_w} + \pi = \left(\frac{D \sin\theta}{2\lambda_o}\right)(2\pi) + 2\pi n,$$
$$n = -2, -1, 0, 1, 2, \ldots, \qquad (1)$$

where

D = geometric distance measured along the center line

L = geometric distance measured along the center wire

λ_o = freespace wavelength

and

λ_w = wavelength along the center conductor.

The principal beam is determined by the condition (n = 1), or,

$$\theta = \sin^{-1}\frac{(L/\lambda_w) - 1}{D/\lambda_o}. \qquad (2$$

To illustrate, for $L/\lambda_w = 1$, $\theta = 0°$ (broadside radiation) for $L/\lambda_w = 2$ and $D/\lambda_o = 1$, $\theta = 90°$ (endfire radiation)

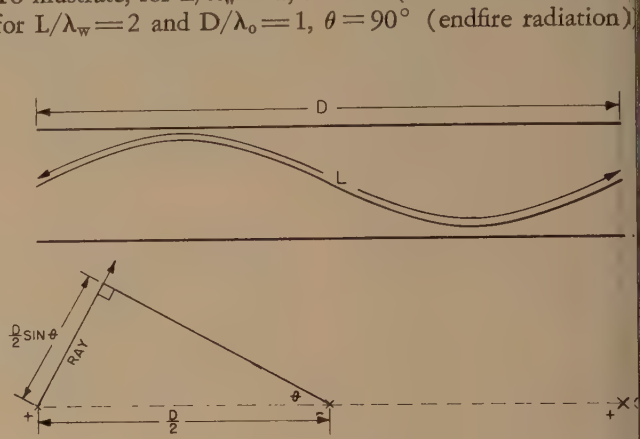

Figure 3 — Analysis of sandwich-wire antenna.

The three-conductor array described has a bidirectional pattern in the transverse plane. A unidirectional pattern can be obtained by placing a conducting sheet at a distance of a quarter-wavelength behind the radiators. The conductors can be supported by quarter-wave metal insulators extending from this sheet.

A printed circuit version of the sandwich-wire array can be realized by extending the two outer grounded conductors back to the reflector to form a cavity. The center conductor can then be printed on a dielectric sheet (Figure 4), which is placed over the open side of the cavity. Many of these arrays can be printed on a single large sheet of dielectric and mounted adjacent to one another to form a two-dimensional flat-plate antenna (Figure 5) that radiates a pencil beam. The distributive feed for these arrays can be of many types, including the stripline corporate structures[5] and similar power-dividing networks. These printed antenna structures can of course be curved to fit contours such as the fuselages of aircraft.

The structures described in the preceding summary are designed to radiate from a surface into space. For illuminating a region between parallel plates, a line source can

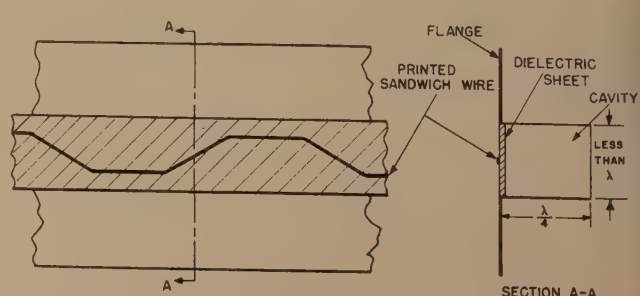

Figure 4 — The sandwich-wire antenna with cavity backing

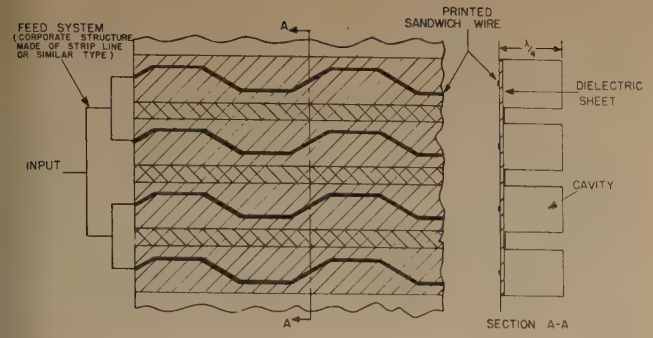

Figure 5 — Two-dimensional array of sandwich wires with cavity backing.

be obtained by extending the outer conductors into large parallel sheets. Such radiators are useful as primary sources for parallel-plate scanning systems, such as the Foster scanner, and for cylindric reflectors and lenses.

2. Sandwich Wire Radiating Element

The traveling wave on a sandwich wire antenna is characterized by a complex propagation constant composed of attenuation and phase factors whose values must be known before an array of optimum radiation characteristics can be designed. Since these quantities cannot be predicted by any known theory, they require experimental measurements.

The dimensions of an experimental element that radiates broadside at a design frequency of 2.8 kMcps are shown in Figure 6. In the test sections constructed the undulation of the center conductor is of uniform amplitude along the entire length. In such uniform sections the field decreases exponentially with distance along the line away from the source. The attenuation constant is directly related to this rate of decrease; the phase constant is approximately related to the direction of the peak of the radiated beam, by Equation (2). (This phase relation is strictly true only for uniform or symmetric amplitude distribution.) Measurements of the radiation patterns show that the phase velocity corresponds to that of a wave traveling along the arc length of the center conductor with a velocity of about 95 percent that of free space ($\lambda_w \sim 0.95\lambda_o$). The reduction in

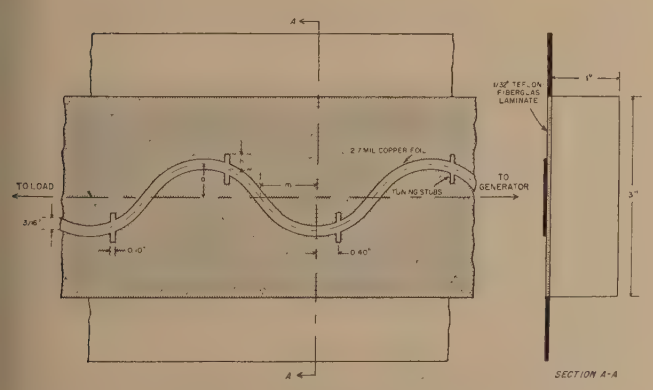

Figure 6 — Dimensions of printed sandwich-wire antenna.

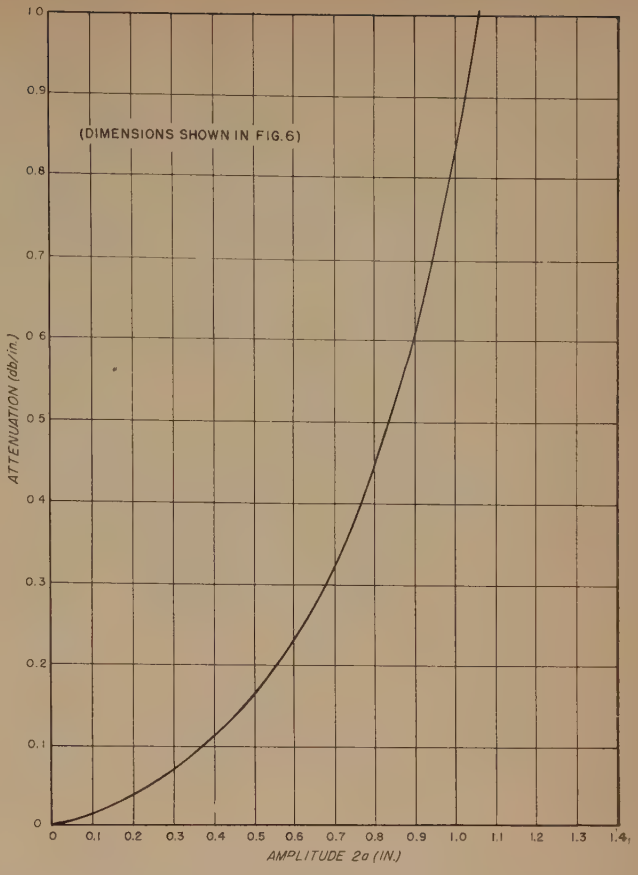

Figure 7 — Attenuation characteristics of a printed sandwich-wire antenna ($L = \lambda_w = 0.95\,\lambda_o$; $f_o = 2.8$ kMcps).

velocity is chiefly the effect of the dielectric that supports the center conductor.[6]

The attenuation constant per unit length of this radiator is a function of the amplitude of the sinusoidally varying center conductor as shown in Figure 7, a curve obtained by probing the fields on the center conductor and observing their exponential decrease in intensity. To obtain broadside radiation, the arc length of each period of the sinusoidal center conductor is made equal to 95 percent of the freespace wavelength.

In broadside radiation, the changes in characteristic impedance of the undulating center conductor cause reflections that add up in phase at the input to give a high VSWR. These reflections are compensated for by small capacitive stubs placed at half-period intervals along the line. The size of each capacitive stub is determined by the amplitude of the sinusoidal center conductor for the particular half-period it corrects. The required stub height is shown in Figure 8. Relatively small compared with the wavelength, and balanced with respect to the center conductor, the stubs do not radiate substantially. This distributive type of stub-matching is quite broadband and compensates for the impedance mismatch over ranges as great as 30 percent.

The stub parameters were determined by measurements of the input VSWR on straight sections of the center conductor feeding the undulations. These measurements could not be made conveniently in the coaxial transmission line that fed the sandwich wire array because the coaxial transition to the stripline was not

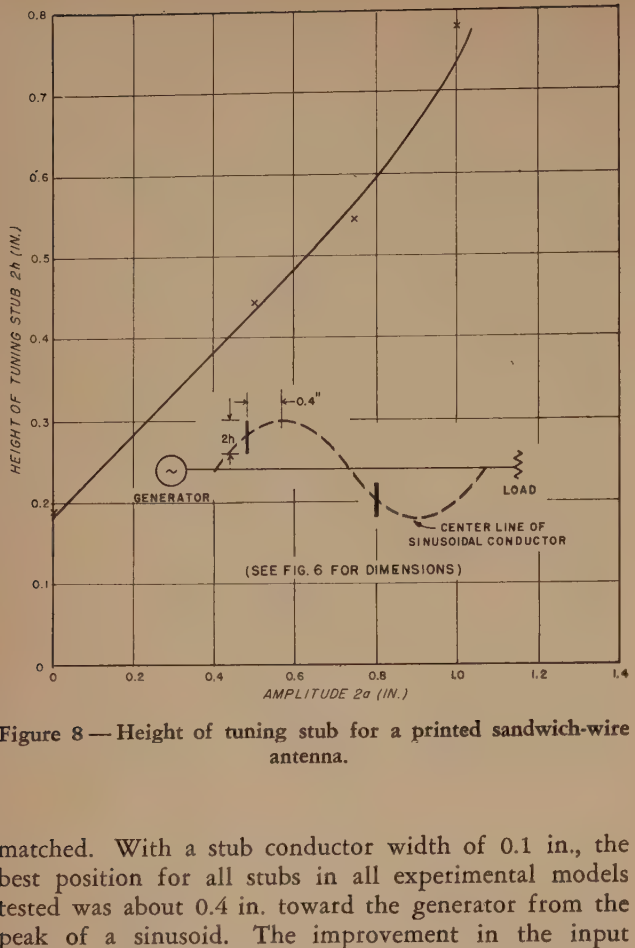

Figure 8 — Height of tuning stub for a printed sandwich-wire antenna.

matched. With a stub conductor width of 0.1 in., the best position for all stubs in all experimental models tested was about 0.4 in. toward the generator from the peak of a sinusoid. The improvement in the input VSWR caused by stub compensation is substantial.

In the models used for determining the phase velocity and attenuation constant, the undulations were all of uniform amplitude, which gave an exponential aperture illumination. To obtain low side lobes, however, the distribution must be tapered by varying the amplitude of the sinusoid as a function of distance along the array. The required attenuation at each point $\alpha(Z)$ can be computed from the relation:[7]

$$2\alpha(Z) = \frac{A^2}{\int_Z^L A^2 dZ + \frac{P(L)}{P(O) - P(L)} \int_0^L A^2 dZ} \frac{\text{nepers}}{\text{unit length}} \qquad (3)$$

where

α = attenuation constant
Z = distance from load along array
A = amplitude of radiation
P(L) = power dissipated in load
P(O) = power at input.

A typical sandwich-wire radiator had the following parameters:

Design frequency	$f_o = 2.8$ kMcps
Angle of emerging beam	$\theta = 0°$
Percentage of power radiated	80 percent
Length of array	L = 24 in.
Amplitude distribution	$A(Z) = 1 - \left(\frac{Z}{L}\right)^2$.

Models of this linear array, both with and without stub compensation, were constructed to check the radiation patterns. The attenuation constant was computed by means of Equation (3). Design parameters such as stub

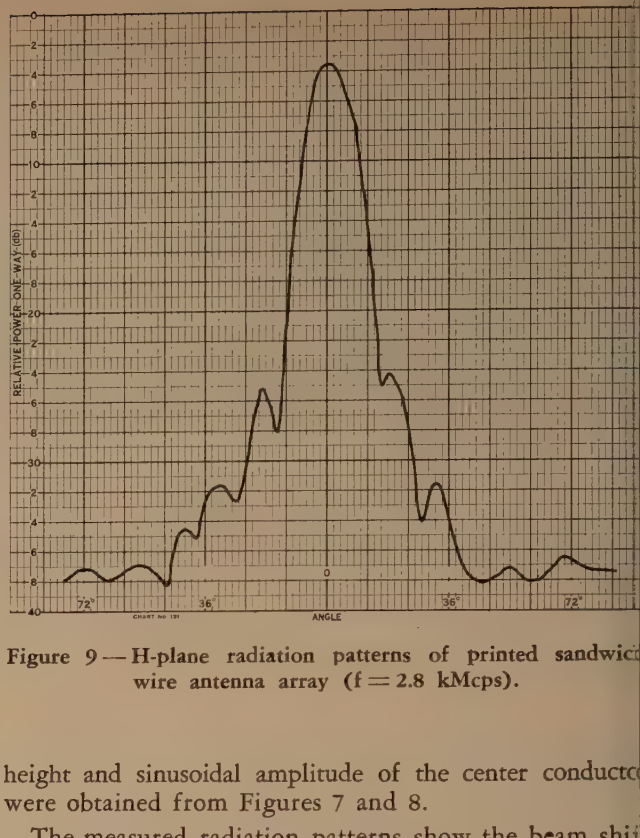

Figure 9 — H-plane radiation patterns of printed sandwich wire antenna array (f = 2.8 kMcps).

height and sinusoidal amplitude of the center conductor were obtained from Figures 7 and 8.

The measured radiation patterns show the beam shift that would be expected from Equation (2). Over a frequency range of 2.6 to 3.2 kMcps, the sidelobe level remains at the theoretical design value of 20 db for the stub-compensated model. A representative H-plane pattern (Figure 9) at the design frequency shows the same general characteristics of beam-width and sidelobe structure as for other frequencies at which the beam is not broadside.

The model without stubs, on the other hand, has sidelobes as bad as 13 db at the design frequency and better sidelobe structure at other frequencies. This pattern deterioration in the absence of stubs is probably due to local traveling-wave reflections that change the amplitude distribution. At frequencies other than for broadside radiation, these reflections do not add up in phase and hence do not significantly degrade the radiation patterns.

An array of six of the stub-compensated sandwich wire radiators was constructed to demonstrate how large flat areas can easily be converted into radiating surfaces. The radiators, feed, and stubs were all printed on a single sheet of dielectric (Teflon-Fiberglas, 1/32 in. thick). Figure 10 shows the array and the resistive termination (lossy dielectric) at the end of each radiator. The metal cover for the stripline feed was removed for this photograph. The radiators were fed in phase by means of a stripline corporate structure (equal path length) feed system, chosen because it was simple in design and construction and could be printed on the same dielectric sheet as the radiators.

The corporate structure feed is essentially a power divider network in which input power is subdivided by successive T junctions to a multiple of outputs. The outputs remain in phase over a moderate frequency range since the electrical lengths from the generator to each radiator are made electrically equal for all ele

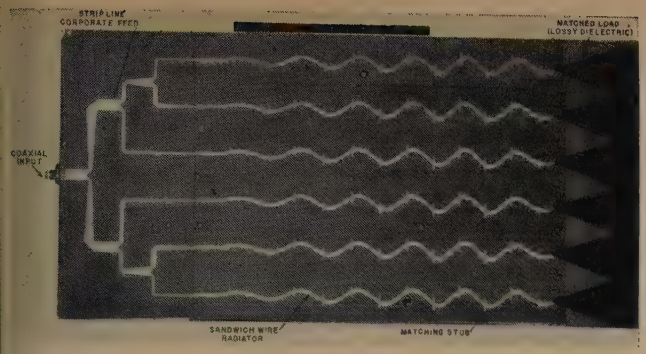

Figure 10 — Model of sandwich-wire antenna array.

ments. Impedance compensation of the T junctions is provided by 90°V notches cut into the tee on the side opposite the input line. A mitered cut is used to compensate for the bends.[5] The output power distribution between the individual elements can be made to assume any desired form by proper manipulation of the characteristic impedance of the T junctions.[8] The E- and H-plane patterns of a rectangular array are completely separable. The H-plane patterns depend only on the characteristics of the radiators — the geometric configuration, the length of array, and the type of termination — whereas the E-plane patterns are primarily a function of the corporate feed system. Thus the measured H-plane patterns for the flat plate array were identical to those measured for the individual stub-compensated radiator. The E-plane radiation patterns (Figure 11) show sidelobes at about 13 db, a level higher than might be expected from a corporate structure feed with tapered illumination. No attempt was made to improve the corporate structure, however — although this can easily be done — because this study was undertaken primarily to evaluate the sandwich-wire radiator rather than the feed system.

The flat-plate array was tested for cross polarization in both the E and H planes. The cross-polarized component was at least 18 db below the level of the principal fields.

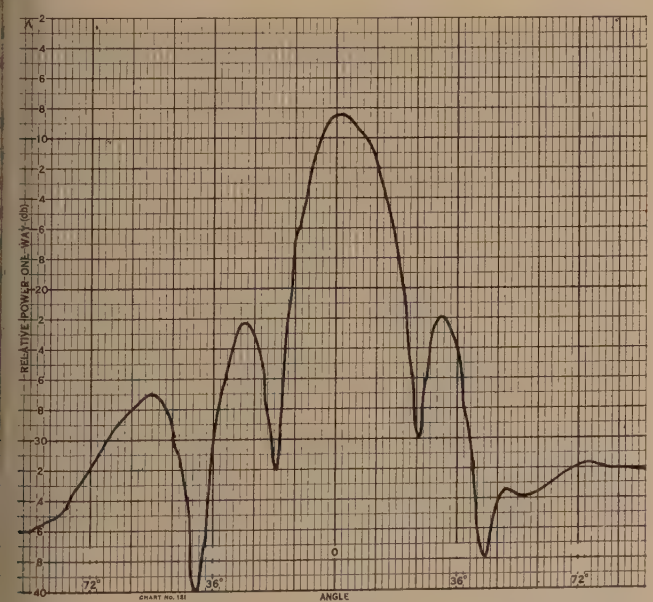

Figure 11 — E-plane radiation patterns of printed sandwich-wire antenna array (f = 2.8 kMcps).

4. Cylindrical Sandwich Wire Array

A major advantage of the sandwich-wire printed-circuit array is the comparative ease with which an array can be made to fit curved contours such as the fuselage of an aircraft or the surface of a missile. For example, the dielectric sheet with printed conductors used for the flat-plate array was curved onto a portion of a circular cylinder 20 in. in diameter. The radiators were arranged parallel to the longitudinal axis of the cylinder and backed up by cavities a quarter-wave deep. The corporate structure feed was slightly modified to give the proper phase for radiators disposed on the arc of a circle. Instead of the 6 used for the flat-plate array, only 4 radiators were excited.

The results were in substantial agreement with those for the flat array. The longitudinal (H-plane) patterns had the same beam-width and sidelobe level. In the transverse (E-plane) pattern the sidelobes were 13 db down at the design frequency, a level commensurate with the uniform power division used between the radiators. The E-plane beamwidth was wider (about 18°) than that for the flat-plate models since only 4 radiating elements were used. This modification of the flat-plate structure to a cylindrical surface demonstrates that the printed sandwich-wire array can be adapted to surfaces of arbitrary contour.

5. Conclusions[9]

The sandwich-wire antenna is a new form of linear array in which the phase and amplitude can be accurately controlled over the aperture. This versatility permits the generation of shaped beams as well as narrow-beam radiation. In pencil beam applications the position of the beam shifts with the frequency just as it does in any end-fed traveling-wave array but the impedance discontinuity that usually accompanies broadside radiation in a traveling-wave array of resonant elements is absent. The attenuation constant is a slowly varying function of frequency. These factors combine to make the sandwich-wire array inherently a broadband device.

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ABSTRACT

A theory describing the operation of a backward-wave reactance amplifier (analogous to the backward-wave tube amplifier) has been worked out, and a low-frequency prototype constructed. This amplifier has a low noise figure and a narrow amplification bandwidth that can be rapidly tuned over a wide frequency range. The theoretical work is applicable at microwave frequencies as well as at low frequencies, and as variable capacitance diodes useful at microwave frequencies become more readily available, microwave models of the BWRA can be constructed. The information contained in this paper should, therefore, be of general interest to workers in the field of low-noise microwave amplifiers.

LOW FREQUENCY PROTOTYPE BACKWARD-WAVE REACTANCE AMPLIFIER*

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I. GENERAL

There is a solid-state reactance amplifier analogous to the backward-wave tube amplifier. This device, called the backward-wave reactance amplifier (BWRA), is capable of providing a low noise figure and a narrow amplification bandwidth rapidly tunable over a wide frequency range. As in all reactance amplifiers, gain is provided through the action of a "pump" voltage that periodically varies some reactance (typically the reactance of a P-N junction diode). In the BWRA, the tuning of the narrow amplification band can be accomplished solely by varying the frequency of the pump oscillator. Thus, if the pump oscillator is voltage-tunable, the amplification band of the BWRA can be voltage-tuned. Furthermore, the BWRA and its pump source can be completely solid-state devices and consequently provide extremely long life and reliable operation.

In a typical configuration for the BWRA, the signal frequency and the idler frequency (corresponding to the difference between the pump and signal frequencies) propagate on one transmission line, and the pump signal propagates on a second transmission line coupled to the first through the nonlinear reactances. As in all reactance amplifiers, the idling frequency is generated by the nonlinear reactance. However, the BWRA provides signal gain in only one direction and idler gain only in the opposite direction. If the output end of the idler line is matched, a signal at the idler frequency appearing at the normal signal input terminals receives no gain whereas the desired signal is amplified. Consequently, unlike the parametric beam tube or the broadband traveling-wave reactance amplifier, the BWRA need not have a spurious response at the idling frequency.

The major contribution to the noise figure of the BWRA comes from thermal noise originating in the load resistance used to terminate the idler signal. If it is permissible to cool the load resistor terminating one port of the BWRA the noise figure can be improved substantially. This cooling can either be accomplished by refrigerating the load resistor or, if the amplifier is operated in a frequency range where antenna noise temperatures below normal room ambient of 290°K result, the antenna itself can be used as a cold termination (for example, between 1000 and 10,000 Mc, antenna noise temperatures will ordinarily lie between the limits of 20°K and 150°K depending on antenna orientation).

A theory describing the operation of the BWRA has been worked out, and a low-frequency prototype constructed. The performance of the prototype correlates quite closely with theoretically predicted values. The theoretical work is applicable at microwave frequencies as well as at low frequencies, and as variable capacitance diodes useful at microwave frequencies become more readily available, microwave models of the BWRA can be constructed. Therefore, it is believed that the information contained in the following sections should be of general interest to workers in the field of low-noise microwave amplifiers.

II. THEORY OF OPERATION

Low-noise broad-band traveling-wave reactance amplifiers, analogous to conventional traveling-wave tube amplifiers, have recently been described (references 1, 2, 3 and 4). P. K. Tien has shown (reference 5) that, theoretically, the traveling-wave reactance amplifier can be operated in other than a broad-band mode. In particular, he analyzed a narrow-band widely tunable mode of operation, analogous to that of the conventional backward-wave tube amplifier. A low-frequency prototype of such a backward-wave reactance amplifier (BWRA) has been designed and tested at this Laboratory. This prototype has an effective input noise temperature less than 220°K over

*This work was performed under Air Force Contract AF30 (602)-1854.

tuning range of 1.7 to 1 when operated at room temrature. In this section some extensions of Tien's theory, ith particular application to the prototype BWRA, are st discussed. Following this, the experimental results e summarized.

Tuning of the BWRA can be accomplished solely by rying the pump frequency. It is of interest to calculate e midband signal and idler frequencies corresponding each value of pump frequency. Amplification in the ckward-wave mode requires that the following condiins be met,

$$f_o = f_1 + f_2 \tag{1a}$$

$$\beta_o = \beta_2 - \beta_1 \tag{1b}$$

here f_0, f_1, and f_2 are, respectively, the pump, signal, and ler frequencies, and β_0, β_1, and β_2 are the corresponding ase constants of propagation. For practical solutions of uation 1, the three waves cannot all propagate with the me velocity, in contrast to the broad-band case. It is ssumed here that the signal and idler waves propagate on ne lossless transmission line (with $f_1 < f_2$), and the ump wave propagates on a second lossless line coupled the first through the nonlinear reactances. Then,

$$\beta_0 = \frac{2\pi f_0}{v_p} \tag{2a}$$

$$\beta_1 = \frac{2\pi f_1}{v_s} \tag{2b}$$

$$\beta_2 = \frac{2\pi f_2}{v_s} \tag{2c}$$

here v_p and v_s are the phase velocities on the pump and gnal lines. Finally, substitution of equation 2 into equaon 1 gives

$$f_1 = \frac{f_0 (1-r)}{2} \tag{3a}$$

$$f_2 = \frac{f_0 (1+r)}{2} \tag{3b}$$

here $r = v_s/v_p$ $(r < 1)$. Under these conditions, as Tien as shown, the idler wave travels in the same direction as ne pump wave, whereas the signal wave travels in the pposite direction.

Two possible limitations on the tuning range of the WRA are:

1. The signal line should cut off at a frequency lower than the pump frequency, to ease the problem of filtering out the very large pump voltage in subsequent stages.
2. The lowest idler frequency should be greater than the highest signal frequency, since it may be desirable to separate signal and idler channels by filtering at the input and/or output ports of the BWRA — for example, to prevent radiation of the idler signal from the input port.

If the lowest and highest values of pump frequency are denoted by f_{OL} and f_{OH}, the above two limitations correspondingly reduce to

$$f_{OL} > \frac{f_{OH} (1+r)}{2} \tag{4a}$$

$$\frac{f_{OL} (1+r)}{2} > \frac{f_{OH} (1-r)}{2} \tag{4b}$$

or alternatively,

$$\frac{f_{OH}}{f_{OL}} < \frac{2}{(1+r)} = 1 + \frac{f_1}{f_2} \tag{5a}$$

$$\frac{f_{OH}}{f_{OL}} < \frac{1+r}{1-r} = \frac{f_2}{f_1} \tag{5b}$$

Assuming the above possible limitations to be in effect, inequalities 5a and 5b determine the maximum tuning range

$$\left[\frac{f_{OH}}{f_{OL}}\right]_{MAX} = \frac{1+\sqrt{5}}{2} \tag{6a}$$

corresponding to a value of

$$\frac{f_1}{f_2} = \frac{\sqrt{5}-1}{2} \tag{6b}$$

Unfortunately, however, the choice of f_1/f_2 for maximum tuning range, as in equation 6b, degrades the noise figure. Tien shows that the minimum noise figure obtainable is determined by the idler noise and is given by

$$F_{min} = 1 + \left(\frac{f_1}{f_2}\right)\left(\frac{T_2}{T_0}\right) \tag{7}$$

where T_2 = absolute temperature of the idler termination, and T_0 = reference temperature of generator = 290°K. Thus, unless the idler termination is refrigerated, low-noise performance implies a small value of f_1/f_2 and hence a small tuning range from inequality 5a.

As in all difference-frequency types of reactance amplifiers, voltage gain can be traded for bandwidth while a constant product is maintained at any one pump frequency. An approximate derivation of this product for the BWRA follows. Generalizing Tien's Section 8, the power gain is

$$\text{P.G.} = \frac{1 + \left(\frac{\Delta\beta}{\xi}\right)^2}{\left(\frac{\Delta\beta}{\xi}\right)^2 + \cos^2\left[\frac{\xi l}{2}\sqrt{1 + \left(\frac{\Delta\beta}{\xi}\right)^2}\right]} \tag{8a}$$

where l is the transmission line length, $\Delta\beta$ is defined in equation 10b, and ξ is defined by equation 13.

When equation 1 is satisfied, $\Delta\beta = 0$, and this is the approximate midband condition. The midband power gain is thus

$$[\text{P.G.}]_0 \approx \frac{1}{\cos^2\left[\frac{\xi l}{2}\right]} \tag{8b}$$

For high gain, the approximate value of $\Delta\beta$ for the half-power bandwidth is

$$\Delta\beta \approx \pm \xi \cos\left[\frac{\xi l}{2}\right], \quad \frac{\Delta\beta}{\xi} << 1 \tag{9}$$

To relate $\Delta\beta$ to the bandwidth $(2\Delta f)$, consider the more general form of equation 1,

$$f_0 = f_1' + f_2' \tag{10a}$$

$$\beta_0 = \beta_2' - \beta_1' + \Delta\beta \tag{10b}$$

where $f_1' = f_1 \pm \Delta f$, $f_2' = f_2 \mp \Delta f$.

Substitution of equations 1 and 2 into equation 10 gives the full bandwidth,

$$2\Delta f = f_1\left(\frac{\Delta\beta}{\beta_1}\right) \tag{11}$$

Next, use of equations 11, 9, and 8b gives the approximate voltage gain-fractional bandwidth product,

$$[P.G.]_0^{\frac{1}{2}} \left[\frac{2\triangle f}{f_1}\right] \approx \frac{\xi}{\beta_1} \tag{12}$$

For the case of a nonlinear capacitance that couples the two lines, ξ is given by

$$\xi = \frac{C_1}{C_0}\sqrt{\beta_1 \beta_2} \tag{13}$$

where C_0 and C_1 are the coefficients in the following expression for the instantaneous value, $C(t)$, of the nonlinear capacitance:

$$C(t) = C_0 + 2C_1 \cos [2\pi f_0 t - \beta_0 z] \tag{14}$$

The ratio C_1/C_0 increases with pump voltage. Finally, substitution of equations 13, 2, and 3 into equation 12 gives the voltage gain-fractional bandwidth product:

$$[P.G.]_0^{\frac{1}{2}} \left[\frac{2\triangle f}{f_1}\right] \approx \frac{C_1}{C_0}\sqrt{\frac{f_2}{f_1}} = \frac{C_1}{C_0}\sqrt{\frac{1+r}{1-r}} \tag{15}$$

Last is considered the number (N) of sections of signal line required for high gain. Here, the signal line is assumed to be a low-pass artificial transmission line, with the shunt element of each section being the average capacitance (C_0) of a pumped nonlinear capacitor (in practice, a reverse-biased junction diode). Then, using Tien's condition for high gain ($\xi l \approx \pi$),

$$N\left(\frac{C_1}{C_0}\right)\sqrt{\beta_1 \beta_2} \approx \pi \tag{16}$$

where exact equality implies oscillations. In equation 16, all quantities are now per section of signal line, rather than per unit distance. Substitution of equations 2 and 3 into equation 16 then gives

$$N \approx \frac{\pi\,(f_s/f_0)}{(C_1/C_0)\sqrt{1-r^2}} \tag{17}$$

where the cutoff frequency of the signal line $f_s = v_s$ The choice of N can now be made from equation 17 us the largest expected value of f_s/f_0 (at most, unity fr limitation 1 on the tuning range) and the highest pected value of C_1/C_0. Then, as the pump frequency raised to cover the tuning range, the pump amplitude m be reduced to satisfy equation 17 by reducing $C_1/$ One further result, that the voltage gain-bandwidth pr uct is approximately constant over the tuning range, is tained by substituting equations 17 and 3a into eq tion 15:

$$[P.G]_0^{\frac{1}{2}} \; [2\triangle f] \approx \frac{\pi f_s}{2N} = \frac{v_s}{2N} \tag{1}$$

III. EXPERIMENTAL DATA

Figure 1 is a schematic diagram, and Figure 2 a pho graph of the prototype BWRA. As discussed in refere 3, this circuit is the low-frequency analog of the balanc line microwave structure used by Engelbrecht in the c struction of a traveling-wave reactance amplifier. Desi values of parameters for a 1.5: 1 tuning range are listed Table I (compare with Table I of reference 4).

TABLE I

PARAMETER VALUES OF PROTOTYPE BWR

$f_0 = 4.5$ to 6.75 Mc
$f_s = 4.5$ Mc
f_p (cutoff frequency of pump line) $= 13.5$ Mc ($r =$
R_s (characteristic impedance of signal line) $= 750$ oh
R_p (characteristic impedance of pump line) $= 50$ oh
$N = 15$
$V = 2.5$ volts
Diodes = matched pairs of Pacific Semiconductors
Type V33 Varicaps
Maximum $C_1/C_0 \approx 0.25$

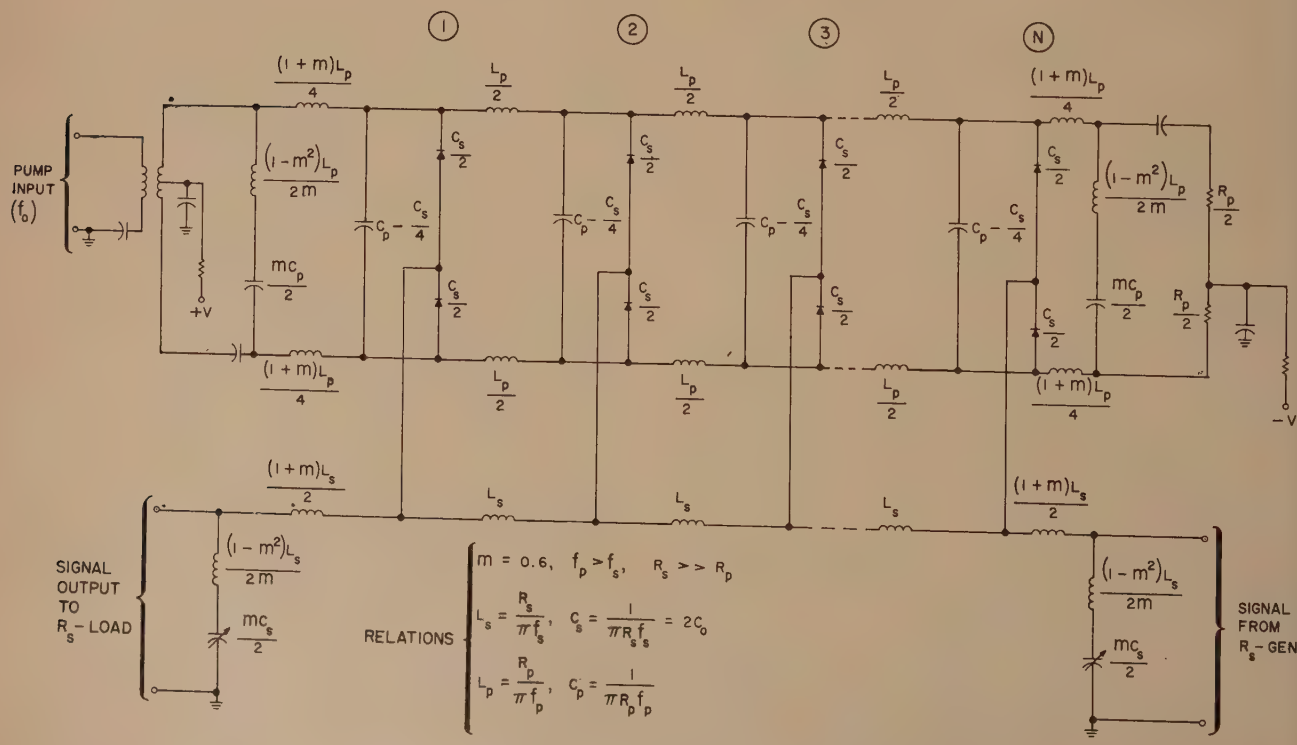


Figure 1 — Schematic diagram of N-section prototype BWRA.

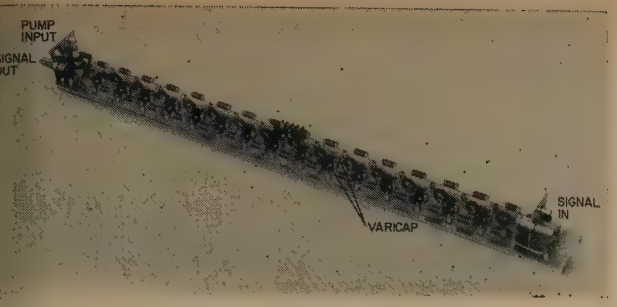
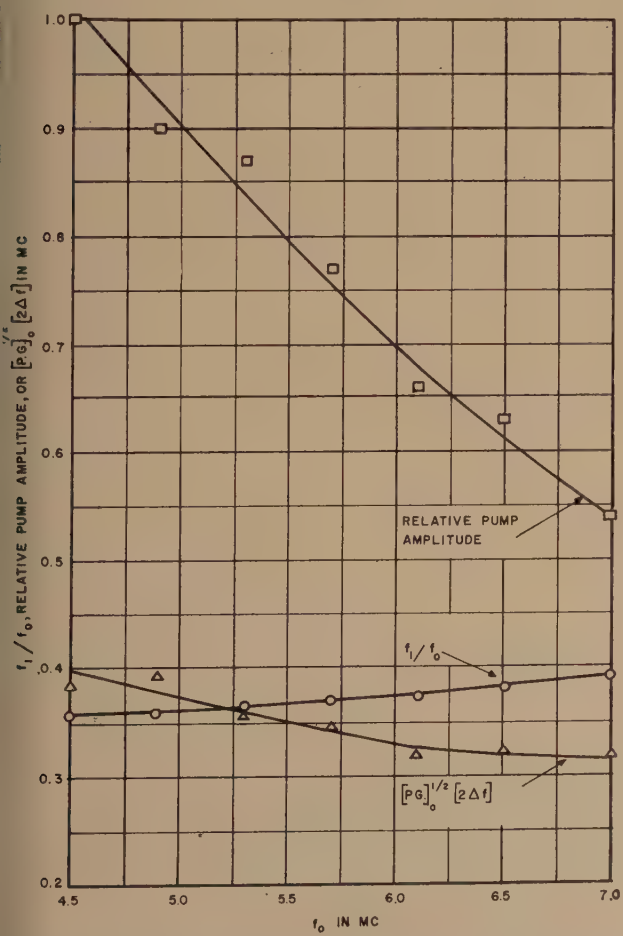


Figure 2 — Prototype BWRA.

nportant measured characteristics of the prototype WRA are summarized in Figures 3 and 4.

Figure 3 includes a plot of the ratio of midband signal equency to pump frequency versus pump frequency. The easured value of 0.36 at the low end of the tuning range grees well with the theoretically constant value of $\frac{1}{3}$ om equation 3a. The slight progressive increase in ratio ith increasing pump frequency is due to the fact that quation 2 holds only approximately for the phase shift n the constant-K artificial transmission line (actually an csin function is involved).

Figure 3 also includes a plot of relative pump input mplitude versus pump frequency for a constant gain of 5 db. As predicted by equation 17, relative pump amplide decreases with increasing pump frequency to maintin the product $(f_0)\ (C_1/C_0)$ approximately constant C_1/C_0 is approximately directly proportional to relative ump amplitude).



igure 3 — Signal-to-pump frequency ratio, relative pump amplitude for constant gain, and voltage gain-bandwidth product of prototype BWRA versus pump frequency.

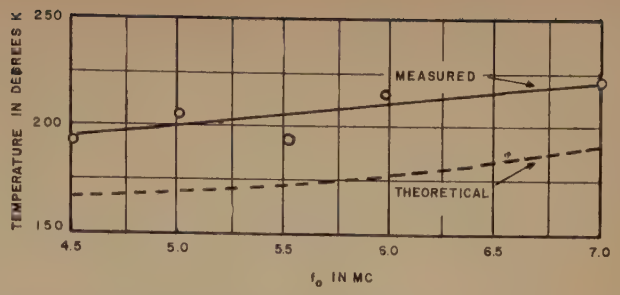


Figure 4 — Midband effective input noise temperature of prototype BWRA versus pump frequency.

Last, Figure 3 includes a plot of voltage gain-bandwidth product versus pump frequency. The measured value of 0.39 Mc at the low end of the tuning range agrees fairly well with the theoretical value of 0.47 Mc obtained from equation 18. Furthermore, the measured product tends to remain constant with increasing pump frequency, as predicted by equation 18.

Figure 4 compares measured and theoretical plots of midband effective input noise temperature versus pump frequency. Measured values were obtained using a temperature-limited diode whose resistive termination was immersed in a liquid nitrogen bath for greater accuracy of measurement. The small post-amplifier contribution (about 20°K) was subtracted from the overall measurements to give the value plotted in Figure 4. Theoretical values were obtained by calculating $(F_{min} - 1)\ T_0$ from equation 7 using f_1/f_2 from Figure 3 and a value of $T_2 = 300°K$. This assumes that the inductances in the signal line are lossless and that the diodes used are ideal nonlinear capacitors. It is believed that the small discrepancy between theoretical and measured plots is attributable to the actual small losses in inductances and diodes. Despite the fact that the above noise measurements were made with a broad-band noise source, the results apply to the case of a narrow-band signal. This is because there are no spurious responses in the BWRA when it is operated—as it was in this case — with the signal and idler matched at both ends of the signal line.

IV. ACKNOWLEDGMENT

We gratefully acknowledge the encouragement and helpful comments of J. C. Greene and the help of A. Barone in construction and measurements.

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This paper describes the methods for designing multi-hole directional couplers employing arrays of round coupling h located in either the common narrow walls or broad walls of two suitably joined waveguides. The equation for each coupl configuration is given so that calculation of the hole sizes can be made for any size waveguide at any frequency in the fundame mode. The design of the simple binomial array and the optimum Tchebycheff array is covered along with superimposed ar of both types. Also included is a discussion which covers the practical considerations involved.

THE DESIGN OF MULTI-HOLE COUPLING ARRAYS

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Circular Coupling Aperture Equations

This paper is concerned primarily with round coupling apertures located in either the narrow walls or broad walls of the waveguide. Of course, there are many other types of coupling apertures which can be considered; however, none of the other types are as simple or yield such excellent results when applied to a practical multi-element array or combination of arrays.

The equation for the coupling obtained from *one* hole located in the common narrow wall between two waveguides joined along the narrow walls is given in Figure 1.

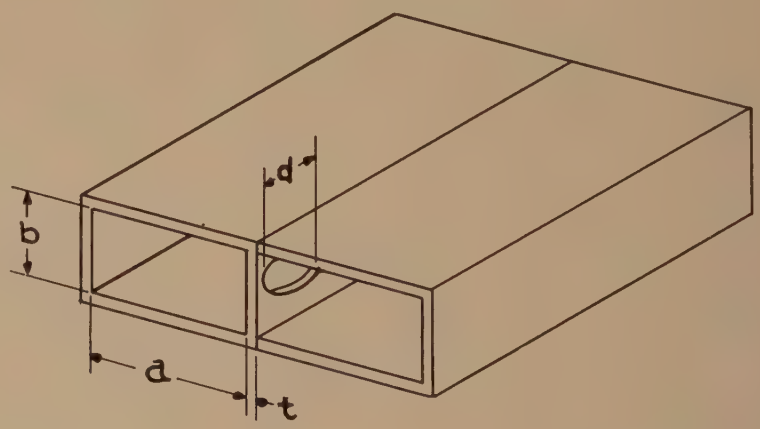
This equation is the standard expression for the coupling of a two hole narrow wall coupler; however, in order to avoid confusion later, the 6.0 db figure is subtracted to reduce the expression to that for one hole only.

The equation for the coupling of one hole located in the common broad wall between two waveguides joined along the broad walls is given in Figure 2.

All parameters in the equation in Figure 2 are as defined in Figure 1 for the narrow wall case. Since the coupling varies as a function of the lateral position of the coupling hole (x), the position which yields minimum frequency sensitivity is used in the derivation of the coupling equation given. This optimum point has been determined mathematically to be approximately one half of the distance between the centerline of the waveguide and the inside of the narrow wall. However, optimum frequency sensitivity is obtained at a point slightly different from the theoretical point, and this should be determined experimentally for each size waveguide. Although the equation gives results based on the theoretical position of the coupling hole, it has been found from experience that the slight change in coupling accompanying a small shift in the coupling hole position does not detract from the usefulness of the equation, since this can be taken into account by a small adju ment factor in the order of 0.3 0.4 db.

Binomial Arrays

The term "binomial" comes abo due to the fact that the relative volta coupling through each coupling ap ture is proportional to the numeri coefficients of a binomial expansi of $(a+b)^{n-1}$, where n equals number of coupling holes. Coupli arrays of this type are superior to



$$C(DB) = 20 \log_{10}\left(\frac{6a^3b}{\pi d^3 \lambda_g}\right) + 32.0\,\frac{t}{d}\sqrt{1-\left(\frac{1.71d}{\lambda_0}\right)^2} - 6.0\ DB$$

WHERE:

- a = INSIDE WIDE DIMENSION OF WAVEGUIDE
- b = INSIDE NARROW DIMENSION OF WAVEGUIDE
- d = DIAMETER OF COUPLING HOLE
- t = WALL THICKNESS IN REGION OF COUPLING HOL
- λ_0 = FREE SPACE WAVELENGTH
- λ_g = WAVELENGTH IN WAVEGUIDE

Figure 1 — Equation for narrow wall coupling.

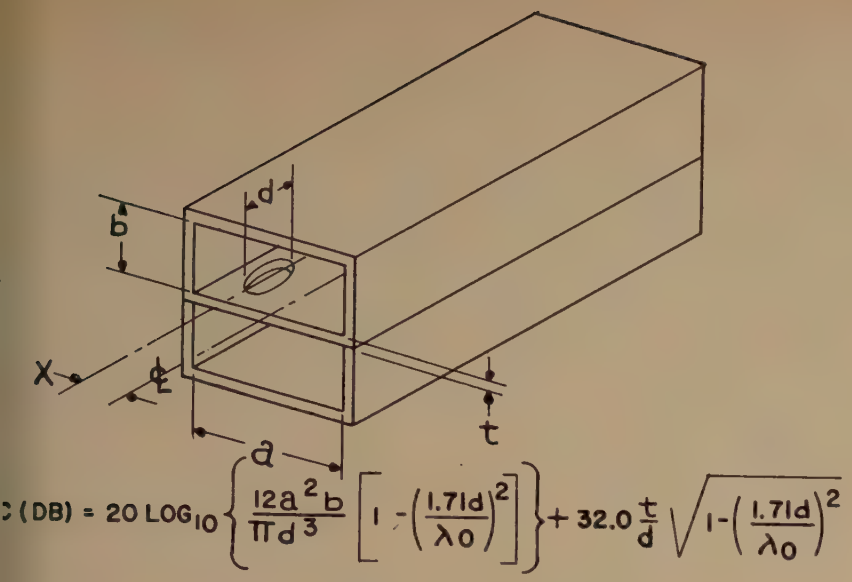


Figure 2 — Equation for broad wall coupling.

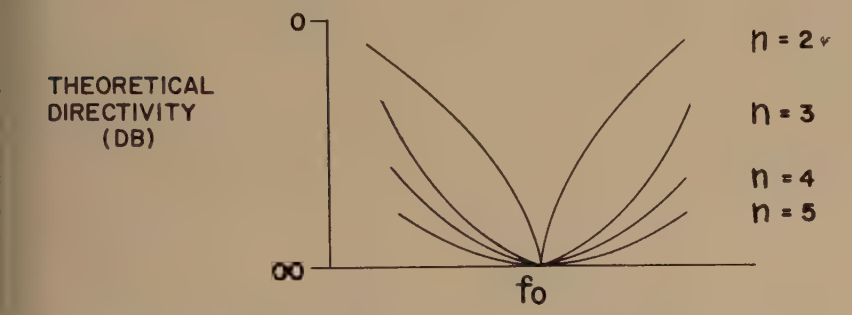


Figure 3 — Directivity vs. frequency for various binomial arrays.

ordinary two hole coupler primarily because of their better broadband directivity characteristics and the tighter coupling which can be attained. The two hole coupler is actually the lowest form of a binomial coupler since the coefficients of $(a+b)^{n-1}$, are both unity when $n=2$. Figure 3 shows the relative differences in broadband directivity between the two hole coupler and binomial arrays where $n=3, 4, 5$.

As shown in Figure 3, the greatest change in directivity is realized between the two hole coupler and the three hole coupler. As more holes are added, the change becomes progressively smaller. However, as n increases, so does the broadband directivity.

The choice of n, or number of holes, is dictated by the minimum directivity and the tightness of coupling desired. Equations have been worked out for calculation of the directivity; however, the strict use of such equations leads to an under-estimation of the number of holes required due to tolerances, imperfections in the waveguide, etc. In general, it is safe to assume that if a minimum directivity of 20 db is desired over a 12 percent bandwidth, at least four or five holes should be used. Greater bandwidths, or greater directivity, require the use of more elements. This latter statement is, of course, very nebulous, but the fact is, if better performance is desired, a simple binomial array should not be used. The use of binomial arrays, therefore, is strictly limited to medium performance applications and values of coupling no tighter than 18 or 19 db.

Figure 4 gives the binomial coefficients and the relative coupling values of each hole expressed in decibels for arrays of two to seven elements. The numbers within the circles represent the binomial coefficients and indicate the relative voltage amplitudes coupled at each element. The numbers below the circles give the coupling values required as determined from the coupling equations.

The development of Figure 4 is quite simple. The binomial coefficients can be determined by either expanding the polynomial $(a+b)^{n-1}$, for the value of n desired, or by starting with the two hole coefficients and adding them together as shown in Figure 5.

The relative coupling of each hole in decibels is calculated by taking the sum of all the voltage coefficients in the array and then taking 20 times the logarithm of the ratio of the sum to the coefficient of the hole in question. For example, for the 4 hole array, the sum is $1+3+3+1=8$, and the coupling of the holes is found by taking 20 log $8/3=8.5$ db, and 20 log $8/1=18.1$ db.

The spacing between holes in a binomial array is always made to be $\lambda g/4$ at the design center frequency in the waveguide size being used. Experimentally, it has been found that the directivity is optimized at the design center frequency when the actual spacing is made approximately $0.975\ \lambda g/4$. If it is found that the diameters of the holes overlap when they have been spaced for optimum directivity, then more holes must be used to achieve the desired coupling, since the diameters decrease for a given value of coupling as the number of holes employed increases. This problem often occurs when the coupler is being designed for the upper end of the waveguide frequency range. Another limited solution is to decrease the waveguide wall thickness.* If these procedures still fail to solve the problem, a "superimposed" array should be used. The design method for superimposed arrays is given later in this paper.

Tchebycheff Arrays

The Tchebycheff array receives its name from the fact that the relative voltage amplitudes coupled at each element are made to be proportional to the coefficients of a Tchebycheff polynomial. This type of array is sometimes called an "optimum array," since its use in coupling structures produces a reverse radiation spectrum which oscillates with equal ripple amplitude about a given value over an extremely broad frequency band without any deterioration at the band edges. This is the characteristic which makes the use of the Tchebycheff array preferable to the binomial array for broad band couplers. Figure 6 shows the relative directivity characteristics between a Tchebycheff array and a binomial array with an equal number of coupling elements.

*See coupling equations in Figures 1 and 2 for the effect of thickness on coupling.

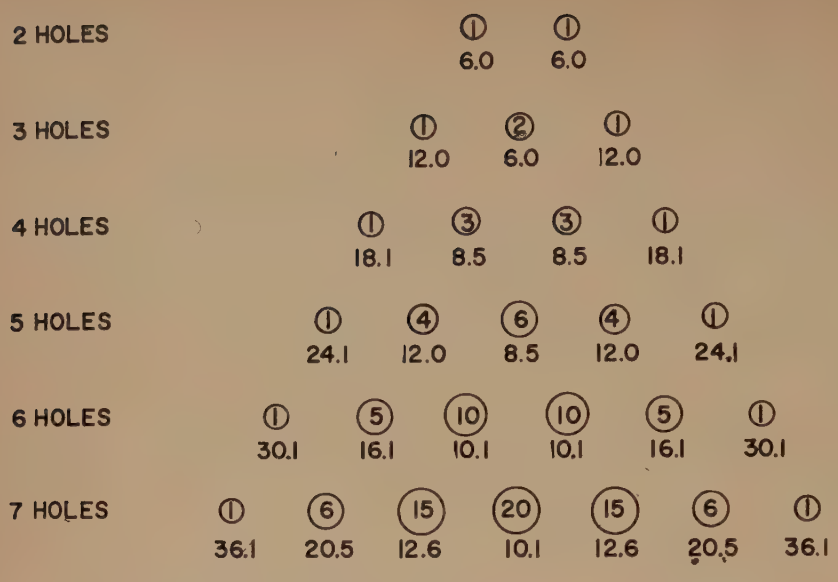


Figure 4 — Binomial coupling coefficients for two to seven elements.

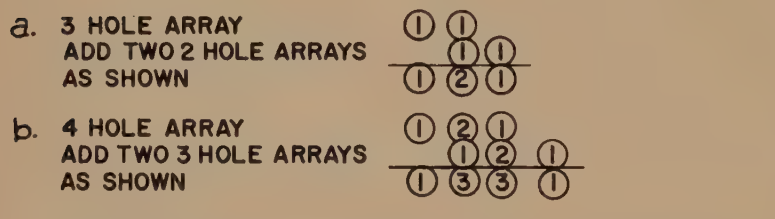

a. 3 HOLE ARRAY
ADD TWO 2 HOLE ARRAYS
AS SHOWN
b. 4 HOLE ARRAY
ADD TWO 3 HOLE ARRAYS
AS SHOWN
C. n HOLE ARRAY
FOR ANY NUMBER OF HOLES(n), CONTINUE ADDING THE
COEFFICIENTS IN THE MANNER SHOWN ABOVE UNTIL
THE DESIRED NUMBER OF HOLES IS OBTAINED.

Figure 5 — Development of Binomial Coefficients.

The design method for the Tchebycheff array is best given by means of an example in order to illustrate the procedure more clearly. The example is worked out for the 8.2 to 12.4 Kmc bandwidth in 1" x ½" waveguide for arrays from two to seven elements.

The first step is to determine the bandwidth ratio p as shown below:

$$p = \frac{\lambda g_1}{\lambda g_2} = \frac{2.402''}{1.123''} = 2.139$$

(where λg_1 and λg_2 are the guide wavelengths at the low and high ends of the desired frequency range)

The spacing between the elements in electrical degrees at the low and high ends of the band, ϕ_1, and ϕ_2, are then determined.

$$\phi_1 = \frac{180^\circ}{1+p} = \frac{180^\circ}{3.139} = 57.34^\circ;$$

$$\phi_2 = 180^\circ - \phi_1 = 122.66^\circ$$

The table shown in Figure 7 is then constructed to relate the wave amplitude coupled through each element to the Tchebycheff response.

The values in the table are found by the following procedure:

(1) Calculate $x_0 = 1/\cos \phi_1 = 1/\cos 57.34^\circ = 1.853$

(2) In the first column, first row, insert the number 2. In the second column, second row, insert the value of x_0 (1.853)

(3) Along the diagonal formed by the number 2 and the value of x_0, insert the value of $(x_0)^K$; e.g., $(1.853)^2$ is placed in the third column, third row, and $(1.853)^3$ is placed in the fourth column, fourth row, etc.

(4) For any other square in the first column, multiply the element above and to the right by $2x_0$, and then subtract the element in the second row above the entry to be found; e.g., the value for the element in the first column, third row is found by multiplying 1.853 by 3.706 = 6.869 then 6.869 − 2 = 4.869.

(5) In any other square, add the element appearing one row above and to the left of the entry to be found to the element appearing one row above and to the right of the entry to be found. Multiply this sum by x_0, and then subtract the element in the second row above the entry to be found; e.g., the value for the element in the second column, fourth row is found by adding 4.869 + 3.434 = 8.303 and then multiply

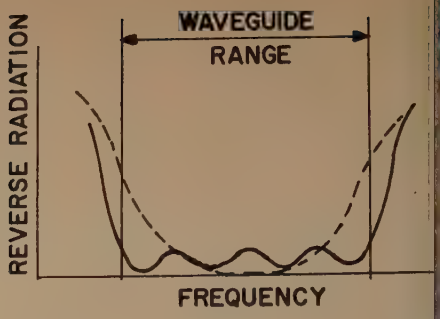


Figure 6 — Comparison of directivity characteristics of Tchebycheff and binomial arrays with an equal number of elements.

n \ K	0	1	2	3	4	5	6
1	2						
2		1.853					
3	4.869		3.434				
4		13.534		6.365			
5	45.294		33.442		11.795		
6		132.380		77.469		21.858	
7	445.373		355.449		172.277		40.507

Figure 7 — Table for calculation of Tchebycheff Coefficients.

ing this figure by 1.853 which equals 15.387, and then subtracting 1.853 from 15.387 = 13.534.

The horizontal rows thus obtained re proportional to the desired voltage oupling for Tchebycheff arrays of two o seven elements for the 8.2 to 12.4 Kmc range in 1" x ½" waveguide. The figures in each row are divided hrough by the smallest number in hat row to obtain ratios with respect o unity. The coefficients are then ummed up and converted to decibels s explained in the section devoted to inomial arrays. The results are tabulated in Figure 8. In this tabulation, he numbers set off by semicolons represent the relative voltage amplitudes, while the numbers in parentheses give he corresponding relative coupling in lecibels.

2 ELEMENTS	1.000; 1.000 (6.00) (6.00)
3 ELEMENTS	1.000; 1.418; 1.000 (10.68) (7.64) (10.68)
4 ELEMENTS	1.000; 2.126; 2.126; 1.000 (15.92) (9.37) (9.37) (15.92)
5 ELEMENTS	1.000; 2.835; 3.840; 2.835; 1.000 (20.76) (11.70) (9.07) (11.70) (20.76)
6 ELEMENTS	1.000; 3.544; 6.056; 6.056; 3.544; 1.000 (26.53) (15.54) (10.88) (10.88) (15.54) (26.53)
7 ELEMENTS	1.000; 4.253; 8.775; 10.995; 8.775; 4.253; 1.000 (31.83) (19.26) (12.97) (11.01) (12.97) (19.26) (31.83)

Figure 8 — Tchebycheff coupling coefficients for two to seven elements — 8.2 to 12.4 kmc in 1" x ½" waveguide.

The spacing between the center ines of the holes in a Tchebycheff rray is given by the following equaion:

$$\text{Spacing} = \frac{\lambda g\, m}{4} = \frac{\lambda g_1\, \lambda g_2}{2(\lambda g_1 + \lambda g_2)} = 0.383''$$

for the 8.2 to 12.4 Kmc band:

$$\text{Spacing} = \frac{(2.402)\ (1.123)}{2(2.402 + 1.123)} = 0.383''$$

The choice of frequency within the operating band at which the hole diameters are determined is not so traightforward. One method is to calculate the coupling by means of the equation at each end of the band and at several points within the band so hat the frequency at which the coupling is a mean value can be approximated. An even better method is to letermine experimentally the frequency sensitivity of the coupling aperture and then choose the frequency where the mean value of coupling occurs. This latter method is preferred for the broad wall coupler since the coupling sensitivity with frequency varies with the lateral position of the coupling hole.

Superimposed Arrays

In many cases arising in directional coupler design, it is not possible to meet all of the electrical and mechanical requirements of a design by using a single binomial or Tchebycheff array. To be more specific, tight couplers such as 3 db or 6 db cannot be designed with a single array of holes because the hole diameters would overlap or the length of the array would become prohibitive. These difficulties can be overcome by designing a "superimposed array" based on the following consideration: The voltage coupling of an array is proportional to the area under the curve of voltage coupling coefficients of the individual elements. The arrays should be added together in such a manner that the resulting composite array is symmetrical with most of the inner holes similar in diameter, otherwise the composite array will be unnecessarily long and its purpose will be defeated. If binominal arrays are used, the directivity function will be binomial in nature, and similarly, Tchebycheff arrays will yield a directivity varying in a Tchebycheff manner. In other words, superimposing arrays will not change the response, except that the directivity will increase as the number of coupling elements is increased.

Figure 9 — (a) Relative magnitudes of voltage coupling coefficients for single array; (b) Superimposing three single arrays.

holes as shown in Figure 9a. If, for example, three identical arrays are superimposed as in the arrangement of Figure 9b, the resulting curve bounds an area three times as great as an individual array. The coupled voltage of the composite array is, therefore, three times as large as that of the individual array, which corresponds to an increase in coupled power of 9.5 db.

The example given in Figure 9 illustrates the addition of three ten-hole arrays; however, this procedure works in general for any number of single arrays with any number of individual

An example of this method is given for a 6 db broad wall to broad wall coupler to cover the 8.2 to 12.4 Kmc frequency range in 1" x ½" waveguide.

(1) Referring to Figure 8, the coefficients for a six hole Tchebycheff array are chosen arbitrarily and six such arrays are added together as shown below to arrive at the total voltage coupling coefficients in the composite array:

1.000; 3.544; 6.056; 6.056; 3.544; 1.000
1.000; 3.544; 6.056; 6.056; 3.544; 1.000
1.000; 3.544; 6.056; 6.056; 3.544; 1.000 etc. until six such arrays are so arranged.

Sum: 1.000; 3.544; 6.056; 7.056; 7.088; 7.056; 7.056; 7.088; 7.056; 7.056; 7.088; 7.056; 7.056; 7.088; 7.056; 7.056; 7.088; 7.056; 6.056; 3.544; 1.000 (21 elements total)

(2) In order to arrive at the relative coupling in decibels for each element, the first step is to add up the total value of the array. This total equals 127.200. The relative coupling values are computed below.

$$20 \log \frac{127.2}{7.088} = 25.08 \text{ db}$$

$$20 \log \frac{127.2}{7.056} = 25.12 \text{ db}$$

$$20 \log \frac{127.2}{6.056} = 26.44 \text{ db}$$

$$20 \log \frac{127.2}{3.544} = 31.10 \text{ db}$$

$$20 \log \frac{127.2}{1.000} = 54.09 \text{ db}$$

(3) Ordinarily, for a 6.0 db coupler, the value of 6.0 db is added to the above figures to arrive at the final coupling values required for each element; however, with the broad wall arrangement, it is much more convenient and economical of length to arrange two parallel rows of coupling holes, one on each side of the centerline of the waveguide. By employing two identical arrays in this manner, each array is then designed for 12.0 db coupling, since doubling the number of coupling elements always increases the overall coupling by 6.0 db.

(4) Therefore, the resulting 6.0 db coupler consists of two parallel rows of 21 holes each drilled approximately half way between the waveguide centerline and the outside narrow walls of the waveguide. The spacing of the holes has already been calculated to be 0.383". The directivity of this coupling design should exceed 40 db over the entire waveguide range if a precision termination with a VSWR of less than 1.02 is used in the secondary guide. The actual hole sizes are obtained from the coupling equation at the frequency corresponding to the mean coupling value.

Practical Considerations

Arrays of coupling apertures other than round holes can be combined in exactly the same way as described. However, it should be emphasized that the broad wall coupling array, whether it be binomial or Tchebycheff, always yields greatly superior coupling sensitivity as a function of frequency. For example, when a coupler is designed to cover an entire waveguide frequency band, the narrow wall coupling array will yield a frequency sensitivity in the order of $\pm$ 2.5 db, whereas a properly located broad wall array will give values of less than $\pm$ 0.5 db. For smaller bandwidths, e.g., 12 percent, coupling sensitivities of $\pm$ 0.1 db have been realized with careful design and control of the coupling element positions.

When using two parallel rows of broad wall coupling holes, some improvement in directivity can be obtained by offsetting each row longitudinally by an amount equal to t hole spacing. This procedure p vides an additional binomial eff since it can be assumed that each ray has similar reverse radiation ch acteristics and the residual amou of reverse radiation from each ar should be cancelled in a manr similar to that of a simple two h coupler.

It has been also found that the u of small holes is preferred over lar ones where enough length is ava able since the coupling equations a derived on the basis of small h theory, and therefore, calculatio are more accurate. Furthermore, the case of broad wall coupling, t equation will show that the f quency sensitivity of small holes less than that of larger holes.

Finally, it must be stressed that t directivity obtained with any dire tional coupler cannot be better th the return loss in decibels of t VSWR of the secondary waveguid termination used. Therefore, it important that the terminati chosen is good enough to utilize t intrinsic directivity of the couplin structure.

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How Indiana Steel's engineers help you solve micro-wave magnetic problems

ngineers at The Indiana Steel roducts Company are in constant ntact with leading manufacturers micro-wave equipment on prob- ms involving permanent magnets. nsultations with Indiana's magnet ecialists have resulted in time and st savings — often eliminating pensive redesign.

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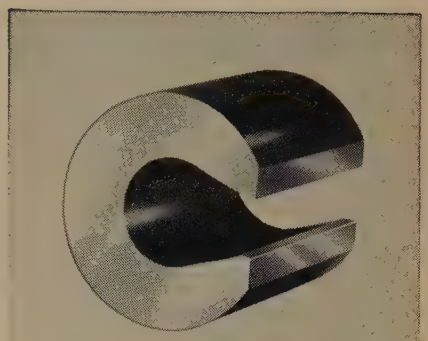
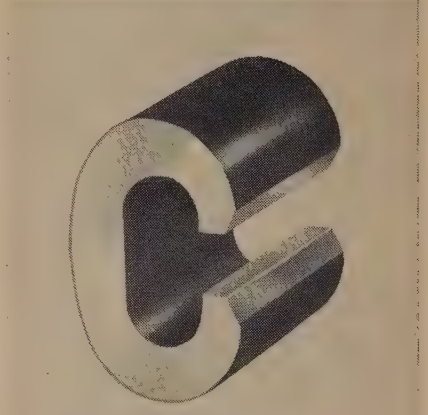


U Magnet

C Magnet



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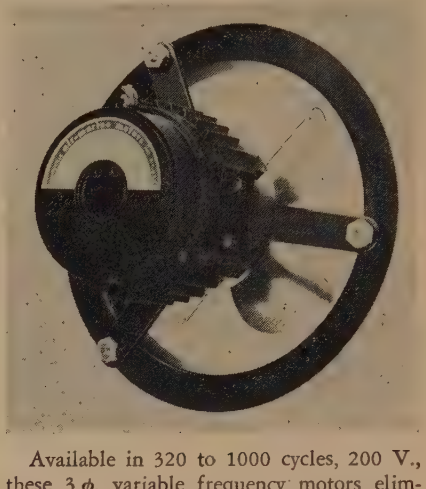
AT —WESCON

AIR-MARINE TO EXHIBIT NEW LINE AT WESCON SHOW BOOTHS 607, 608, 609

Air-Marine Motors, Inc. will display their new line of 3 ϕ, variable frequency axial fans and centrifugal blowers at the WESCON Show.



Available in 320 to 1000 cycles, 200 V., these 3 ϕ, variable frequency motors eliminate the need for running capacitors. The 4" axial fan shown here, a typical unit, delivers 240 C.F.M. at 0" S.P., 400 cycles. Ambient range is —55°C to +125°C.

These units have a typical application in airborne radar cooling and meet MIL-E-5400 and MIL-E-5272A.

Air-Marine Motors, Inc. of Amityville, N.Y. and Los Angeles, Calif. are designers and manufacturers of precision subfractional H.P. motors, blowers and fans.

CIRCLE READER SERVICE CARD 101

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BENDIX RED BANK DIVISION WESCON BOOTHS 2007-2010

Bendix Red Bank announces two additional new tube types to its expanding microwave tube line. These tube types, TE-53 and TE-78, are mechanically tuned Reflex Klystron Oscillators for operation at the extremely high frequencies of 34,000 to 35,600 megacycles per second. Their design features ruggedized mechanical construction, ceramic insulators, dielectric tuning, waveguide output, and an improved electron gun design in order to provide stable operating frequency, optimum electronic tuning and power output with low resonator voltage, reduced power input and long operating life.

These tubes have been designed for in microwave systems such as communications, countermeasures, radar, radio astronomy, spectroscopy, and test equipme They may serve as local oscillators, pu sources, or signal generators in these any other application requiring a relia source of microwave energy.

CIRCLE READER SERVICE CARD

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EG & G WILL SHOW TWO NEW THYRATRONS AT WESCON BOOTHS 3211-3213

Two miniaturized ceramic-metal drogen thyratron tubes will be introduc by Edgerton, Germeshausen & Grier, In in booths 3211-3213 at WESCON in S Francisco, August 18-21.

The new EG & G thyratrons have be designated the HY-1 and the 632. gether with the 1802, which has been production by the firm for more than a ye the tubes will handle all switching pow requirements up to 20 megawatts.

The HY-1 is 2 5/16 x 4 5/8 inc overall dimensions. It is rated 5 megawa 20 KV, 500 amps peak and a Pb factor 10 x 10^9.

The 632 is 1.1 x 1.6 inches overall mensions. It is rated 67.5 KW, 3 KV, amps peak and a Pb factor of 1 x 10^9.

Also to be shown by EG & G for the f time are two grid-controlled ceramic-me hydrogen rectifiers rated 1½ and 5 an with peak input voltage of 27.5 KV.

The scientific instrument firm will a show its 2236A sub-millimicrosecond os loscope and full line of xenon flash tub including the recently-developed FX6A.

CIRCLE READER SERVICE CARD

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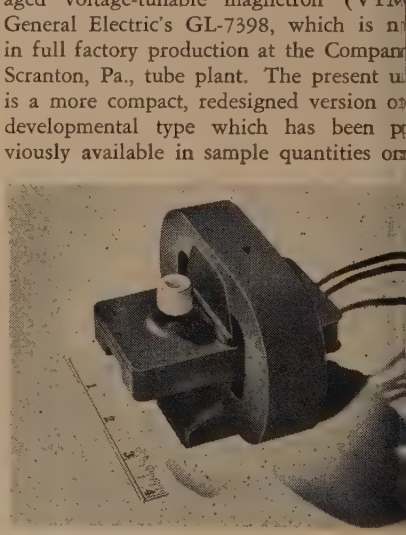
GE SHOWS NEW VTM WESCON BOOTH 2113

GE will exhibit the industry's first pa aged voltage-tunable magnetron (VTM General Electric's GL-7398, which is n in full factory production at the Compan Scranton, Pa., tube plant. The present u is a more compact, redesigned version o developmental type which has been p viously available in sample quantities on



The present VTM package is the same the developmental unit in ratings and p formance. However, certain assemblies h been redesigned to permit easier fact manufacture and thus assure greater liability.

Developmental models of the VTM h received wide acceptance from equipm manufacturers because of their signific

performance improvements, previously unavailable in a microwave oscillator.

A major advantage of the VTM is its rapid, linear tuning characteristic.

CIRCLE READER SERVICE CARD 104

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HEWLETT-PACKARD
BOOTHS 1724,1826-1828

A sampling oscilloscope, capable of resolving pulses up to 500 MC, heads the list of new electronic measuring instruments to be introduced by Hewlett-Packard Company at the 1959 WESCON Show.

The Hewlett-Packard exhibit will include fifteen major instruments, eight of which are being shown for the first time. These will be arranged in actual test setups to demonstrate the speed, convenience and accuracy provided by modern instrumentation.

Among the new instruments to be introduced by the company are:

Model 185A Oscilloscope—Based on a new design principle, this "sampling" oscilloscope provides a clear and steady display of pulses requiring resolution up to 500 MC.

Model 456A ac Current Amplifier — This instrument permits measurement of current on indicating meters such as ac VTVM's or oscilloscopes.

Model 160A 15 MC Oscilloscope — This is a high-frequency, high-performance oscilloscope built to military standards.

Model 466A Transistorized Amplifier — This is a general-purpose instrument amplifier providing standard gains of 20, 40, and 60 db ± 0.2 db from 5 cps to 1 MC.

Model 154A Voltage-Current Dual Channel Amplifier — This instrument measures current qualitatively and quantitatively on an oscilloscope by permitting direct viewing of ac current wave.

Model 393A Variable Precision Attenuator — This is a new two-in-one instrument. As a precision attenuator, it covers 5 to 120 db; comes equipped with removable 50 ohm, 0.5 watt terminating resistors for most applications, and also measures up to 200 watts with higher power terminations. The instrument also serves as a 4-terminal network for sampling power (replacing many fixed directional couplers) or coupling-isolating arrangements involving fixed oscillator, input and mixer.

Model 100E Frequency Standard—This instrument provides a frequency stability of $5/10^8$.

Other Hewlett-Packard instruments to be shown at WESCON include a frequency divider and clock (Model 113AR), electronic counter (Model 523CR), oscilloscope camera (Model 196A), transistorized wave analyzer (Model 302A), transistorized ac voltmeter (Model 403A), clip-on dc milliammeter (Model 428A) and a precision volt-ohm-ammeter (Model 412A).

CIRCLE READER SERVICE CARD 105

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HUGGINS LABORATORIES WILL INTRODUCE NEW TWT AMPLIFIER
WESCON BOOTHS 1918-1920

Tube Type	HA-27
Frequency Range	1.0 to 2.0 KMC
Small Signal Gain	30 db (min.)
Saturated Power Output	5 dbm (min.)
Capsule Length	15-7/8 inches
Net Weight	1.5 pounds

This traveling wave tube represents a remarkable advance in the state of the art of traveling wave tube manufacture. Focusing is accomplished by electrostatic means, employing a set of bifilar helices. The d.c. voltage difference between the two helices (200 volts max.) gives rise to strong electrostatic fields, which confine the flow of the electron beam from gun to collector.

Since the tube uses no magnetic focusing fields, it is relatively insensitive to changes in ambient temperature. Its unique construction eliminates a great deal of the amplitude modulation in the presence of vibration common to other traveling wave tubes. These factors, together with the extremely light weight for the complete package, 1.5 lbs., makes it particularly suitable for airborne applications.

CIRCLE READER SERVICE CARD 106

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MENLO PARK ENGINEERING
WESCON BOOTH 311

Included in our exhibit at the WESCON Show, Booth 311 will be the following NEW units of equipment:

The model TA 36PM permanent magnet focused traveling wave tube amplifier, a lightweight, compact instrument applicable to many uses in the operating frequency range 0.5 to 1.0 KMC. The ruggedized power supply provides 0.1% regulation, with maximum ripple on the helix less than 10 millivolts. Front panel metering provided for helix voltage, helix current, and beam current. The unit has been designed for relay rack or cabinet mounting.

A packaged permanent magnet focused backward wave oscillator which covers the X-Band, providing a minimum of 1 milliwatt power output. Compared to solenoid focused equipment, this unit weighs 50% less. Other advantages include up to 75% less power consumption, and operational ease. Units are available with a delivery schedule of 4 to 6 weeks.

CIRCLE READER SERVICE CARD 107

Please turn to page 46.

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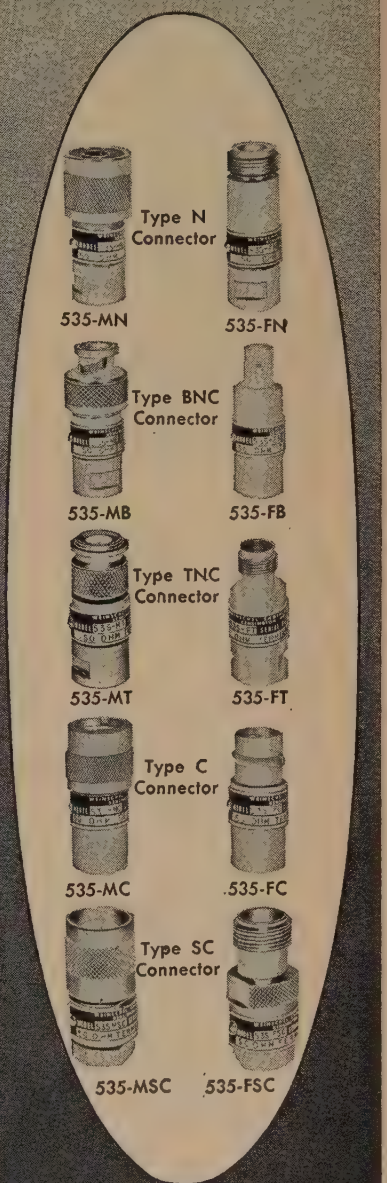

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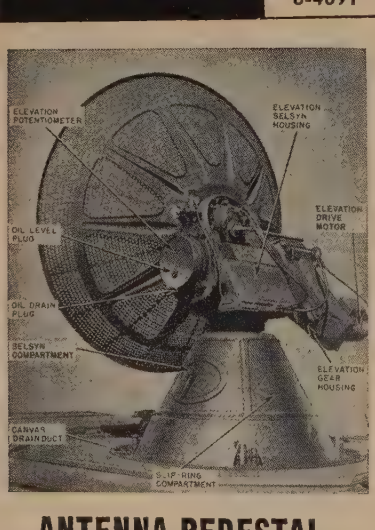

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SANDERS SHOWS NEW TRI-PLATE MODULES

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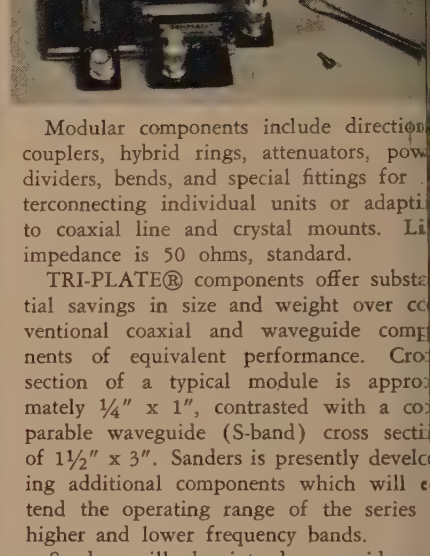
A new series of modular strip transmission line components — which can be assembled in minutes to produce complete circuits for 2-4 Kmc operation — will be introduced by Sanders Associates, In Booths 3013-3015 at Wescon, San Francisco, August 18-21.

Sanders' TRI-PLATE® modules permit quick, easy laboratory breadboarding mixers, duplexers, modulators, and oth circuits encountered in radar, data link, a microwave computer development. Th provide a short-cut to the design of in grated TRI-PLATE® packages, permitti testing and evaluation of the strip tra mission line circuits with a minimum engineering time and cost.



Modular components include direction couplers, hybrid rings, attenuators, pow dividers, bends, and special fittings for terconnecting individual units or adapti to coaxial line and crystal mounts. Li impedance is 50 ohms, standard.

TRI-PLATE® components offer substa tial savings in size and weight over co ventional coaxial and waveguide comp nents of equivalent performance. Cro section of a typical module is appro mately ¼" x 1", contrasted with a co parable waveguide (S-band) cross secti of 1½" x 3". Sanders is presently develo ing additional components which will e tend the operating range of the series higher and lower frequency bands.

Sanders will also introduce a wide va ety of newly developed FLEXPRINT flexible printed circuits, including contin ous-length flexible printed cables, ext high wiring-density circuits, and shield and coaxial cable assemblies.

CIRCLE READER SERVICE CARD 1

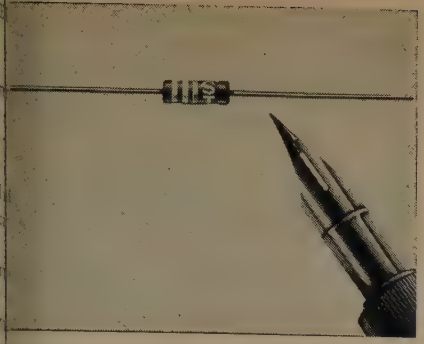
• • •

SILICON TRANSISTOR CORP.

WESCON BOOTH B-1403

A unique series of sub-miniature si con circuit diodes guaranteeing a co trolled forward specification of 0.7 0.74 volts at 10 milliamperes has be announced by Silicon Transistor Cor manufacturers of silicon diodes a power transistors.

The new diode will be shown at WE CON, STC booth number B-1403. T high conductance controlled forward ries, known as types STC 101 throu 108, is now in production and availa for immediate delivery.



The guaranteed forward matching characteristics of this new STC series eliminates the problems that exist in using ordinary matched pairs and quads and makes these sub-miniature diodes ideal for application requiring ultimate reliability, as well as predictable forward characteristics as in transistor biasing, modulator and clamp circuits.

CIRCLE READER SERVICE CARD 109

More WESCON Booth News *on Page 62*

NEW PRODUCTS

1 MEGAWATT X-BAND FERRITE DUPLEXER — MA-124T

Microwave Associates, Inc., of Burlington, Massachusetts, has developed a 1-megawatt peak, 1000-watt average power ferrite duplexer for use in X-band radars operating in the 8500-9600 Mc frequency range.

It features a crystal protector TR tube custom matched to a Microwave Associates ferrite circulator for optimum electrical performance at the full rated power condition.

The MA-124T duplexer includes a life warranty for the crystal protector of 500 hours minimum. Maximum recovery time is 2 microseconds with typical recovery time approximately 1 microsecond at 1 Mw peak input to the circulator and 100 kW typical antenna line mismatch power to the crystal protector TR.

The circulator used with the MA-124T is of the non-reciprocal phase shift type. The unit exhibits a low insertion loss of only .3 db maximum. Transmitter-receiver isolation is 25 db minimum under matched load conditions. Antenna-transmitter isolation is 20 db minimum. VSWR is 1.15 maximum.

Electrical ratings apply over a temperature range of —50°C to +85°C. Unit is liquid cooled with maximum coolant temperature of 65°C specified for one megawatt operation. At lower power levels liquid cooling is not required.

The MA-124 circulator consists of a folded hybrid tee, phase shift section, and short slot hybrid brazed together.

RG-51/U waveguide connections are used throughout for convenient coupling with UG-52/U flanges. Total weight is 4 lbs., 8 oz.

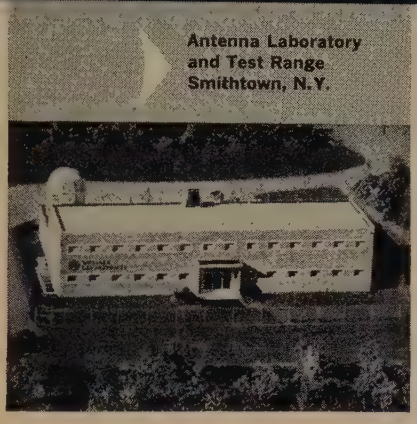
CIRCLE READER SERVICE CARD 110

More new products on page 49.

Main Office and Microwave Laboratory Great Neck, N.Y.

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an independent laboratory devoted exclusively to consulting and development.

WHEELER LABORATORIES, INC.
ON LONG ISLAND



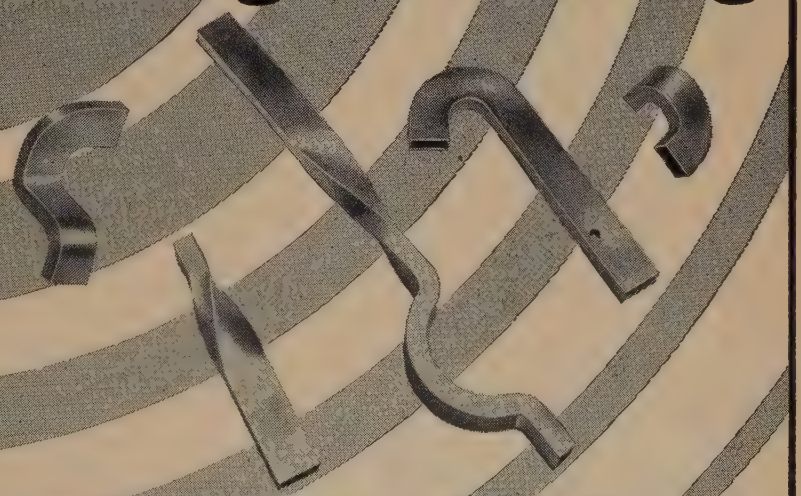
Antenna Laboratory and Test Range Smithtown, N.Y.

As a service to many prominent laboratories and manufacturers, WL has designed antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler and Engineering Staff

CIRCLE READER SERVICE CARD 25

Waveguide
specialists in close tolerance
Bending and Forming



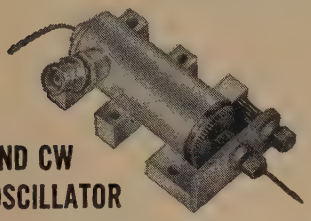
INTASPACE CORP.
135-A ORANGE ST., BLOOMFIELD, N. J.
PILGRIM 8-4700

CIRCLE READER SERVICE CARD 26

NEW!

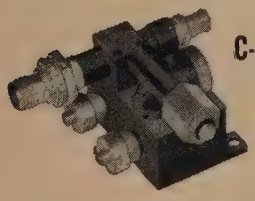
C-Band *System-Tested* MICROWAVE COMPONENTS

Engineered to meet complete Military Missile Specifications



C-BAND CW OSCILLATOR

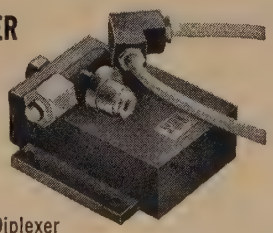
- Minimum 3 mw Power Output
- Adjustable Tuning over a range of 500 mc
- Tube—Triode GZ 5139
- Miniaturized—only 4" long, 1¾" wide, 1¼" high (excluding connector)



C-BAND BEACON FRONT END ASSEMBLY

- An exceptionally compact, lightweight unit, featuring low loss and ultra-high selectivity.
- Extremely small—only 2½" x 2½" x 2"

C-BAND FILTER MIXER DIPLEXER



- Mixer and Diplexer (non-tunable) operate as an integral part of the Filter
- Unit features minimum Insertion Loss, Rejection Bandwidth and Input VSWR
- Tuning Range—minimum 500 mc

WRITE for prices and delivery.

See Avion at WESCON Booth 3815

AVION

FOREMOST IN AVIONICS

ACF INDUSTRIES INCORPORATED

AVION ACF AVION DIVISION

11 Park Place, Paramus, N. J.

CIRCLE READER SERVICE CARD 27

Microwave Engineers

Join long-range, advanced development programs to create new microwave devices

In the Microwave Development Laboratories of the Radio Corporation of America, at Princeton, N. J., and Lancaster, Pa., engineers are engaged in long-range programs on a variety of microwave devices (super power klystrons, grid controlled amplifiers and switch tubes, conventional power level microwave devices, traveling wave tubes, parametric amplifiers and microwave solid state devices, high-speed switches and high perveance electron guns).

In essence, the challenge in the advanced development laboratories is to achieve further advances in these areas of significant scientific importance.

Opportunities are available offering unlimited progress to engineers with PhD and MS degrees (Physics and EE) who can contribute new concepts in these fields or can lead engineering groups investigating new microwave devices and utilizing new operating principles.

INVESTIGATE THESE OPPORTUNITIES—SEND RESUME IN COMPLETE CONFIDENCE:

FOR PRINCETON, N. J.

Mr. J. F. McPartland
Professional Personnel
Dept. J-3H
Radio Corporation of America
Electron Tube Division
Harrison, N. J.

FOR LANCASTER, PA.

Mr. E. F. Stevens, Mgr., Employment
Dept. G-15H
Radio Corporation of America
Electron Tube Division
New Holland Pike, Lancaster, Pa.

At WESCON—Visit our suite in the Convention Hotel.

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA

RADIO CORPORATION of AMERICA

ELECTRON TUBE DIVISION

microwave design engineers

Capable of design and development or application of microwave components and systems. Background in antennas, couplers, mixers, oscillators, phase shifters, duplexers, TR devices or similar complex electronic components or systems desired.

Positions immediately available in any of these project areas

1. High speed voltage tunable microwave receivers
2. Correlation air navigation
3. Missile fuzing

You'll work at General Electric's Light Military Electronics Department, a 6 year old organization with a continuous record of expansion and diversification in advanced areas of electronics.

There's comfortable living for the whole family at our up-state New York location at Utica — a growing, progressive city just a "step" away from Adirondack Summer & Winter resort areas and the beautiful Finger Lakes.

Mail your resume in strict confidence to Mr. William Gilmore, Dept. 127-H

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

New Products (Continued)

WAVEGUIDE QUICK DISCONNECT

Adaptable for use in making quick connections on all types of waveguide components (including most flexible waveguide applications) both in the laboratory and in the field, the Model 3419 Waveguide Quick Disconnect adds very little to the size of the connection and is easily attached to a standard choke flange with two screws. The model 3419 is manufactured by Aircraft Armaments, Inc., Cockeysville, Md.

This coupler offers the utmost in simplicity of operation. After being attached to a choke flange, the mating waveguide cover flange is inserted into the opening in the coupler. A slight CW rotation of the coupler is all that is needed to quickly and securely fasten the two pieces of waveguide together. Alignment of the two sections of guide is assured by the two screws used to mount the coupling. There are no loose parts to be lost, no springs to break, no fingers to bend. The two pieces which are assembled to make this unit are securely fastened together and are made of stainless steel to insure a most durable item. The coupler is made in two sizes . . . one for K-band (Model 3419K), one for X-band (Model 3419X).

An additional feature of the coupler design is its ability to make a connection of two cover flanges as well as one of a choke and cover flange. This feature is very important where the thickness of choke and cover flange differ. The finished appearance of the coupler makes it desirable for front panel attachments.

CIRCLE READER SERVICE CARD 111

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LARGEST STATIC INVERTER FILLS GAP IN STANDBY POWER

Another forward step in the rapidly advancing technique of power transistor applications was taken this month when Transval Electronics Corp., Culver City, California, delivered what is believed to be the world's highest-rated static inverter to Onan & Sons, Inc., Minneapolis. Transval's Model 4058 is said to be the first fully transistorized inverter with 5 kva load rating.

The Transval 5 kva inverter was developed to provide immediate standby power for installations such as microwave communications links where continuity of operation is important. In the event of a failure of power from the primary 110-volt

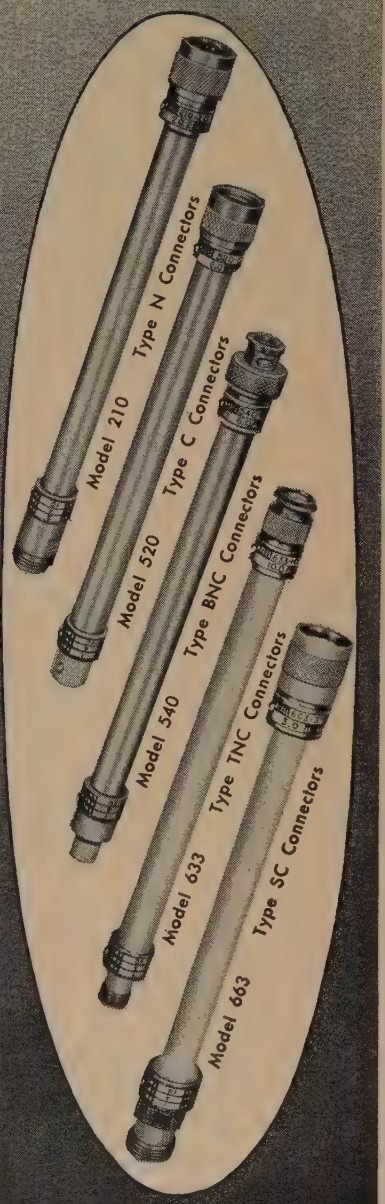
WEINSCHEL

FIXED COAXIAL ATTENUATORS

1 to 12.4 KMC

50 Ohms 1 to 20 db

Connectors: Type N, C, BNC, TNC or SC. Each type with male/female, double male or double female connectors. Made with Weinschel Film Resistors for maximum stability.

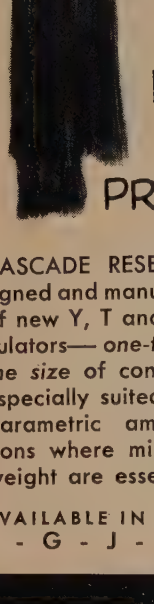

Model 210 Type N Connectors
Model 520 Type C Connectors
Model 540 Type BNC Connectors
Model 633 Type TNC Connectors
Model 663 Type SC Connectors

WE CO

Write for complete catalog, specifying frequency range of interest.

Weinschel Engineering

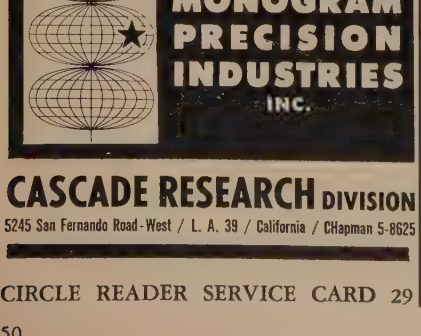
KENSINGTON, MARYLAND



DO *YOU* HAVE A SIZE PROBLEM?

CASCADE RESEARCH has designed and manufactures a series of new Y, T and Cross-type circulators— *one-tenth to one-fifth the size* of conventional types. Especially suited for maser and parametric amplifier applications where minimum size and weight are essential.

AVAILABLE IN THESE BANDS:
S - G - J - X L - X - K



GENERAL SPECIFICATIONS

Peak Power	100 K.W.
Average Power	100 watts
Maximum Insertion Loss	0.5 db
Minimum Isolation	20 db
Maximum V.S.W.R.	1.2
Frequency Band	5% or more

MONOGRAM PRECISION INDUSTRIES INC.

CASCADE RESEARCH DIVISION
5245 San Fernando Road-West / L. A. 39 / California / CHapman 5-8625

CIRCLE READER SERVICE CARD 29

AC line, this type of inverter can be automatically switched into circuit to convert battery power during the interval while auxiliary engine-driven inverter is being started and brought up to speed.

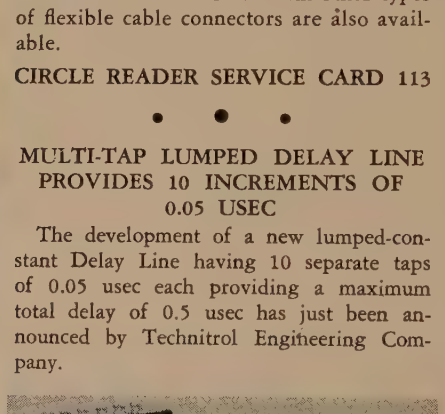
Operating efficiency is better than 90%. An overload feature provides that in case of a short or other cause of overload beyond 6 kva, the Transval Model 4058 Inverter will automatically shut down in order to prevent damage to the device's 68 power transistors. Other specifications: Operates from 36 v d-c power input. Current drain at full (5 kva) load is 150 watts. Output is 115 volts, 60 cycles.

CIRCLE READER SERVICE CARD 112

• • •

NEW INSTRUMENT LOAD BY ALFORD

The AMCI Type 1108B Instrument Load provides a nearly reflectionless termination on a 50 ohm coaxial transmission line over the frequency range of 0 to 1100 mc. The rated VSWR is under 1.02; the rated maximum input power is 0.5 watt.



The Type 1108B Instrument Load is designed around a metal-film-on-glass type of resistor. It is unusually stable. Stability plus low reflection makes this load suitable as a Secondary Standard.

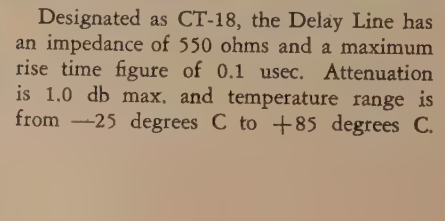
The type 1108B Instrument Load is designed for use with Type N connectors. Instrument Loads for use with other types of flexible cable connectors are also available.

CIRCLE READER SERVICE CARD 113

• • •

MULTI-TAP LUMPED DELAY LINE PROVIDES 10 INCREMENTS OF 0.05 USEC

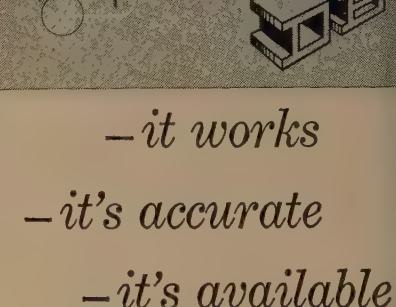
The development of a new lumped-constant Delay Line having 10 separate taps of 0.05 usec each providing a maximum total delay of 0.5 usec has just been announced by Technitrol Engineering Company.



Designated as CT-18, the Delay Line has an impedance of 550 ohms and a maximum rise time figure of 0.1 usec. Attenuation is 1.0 db max. and temperature range is from —25 degrees C to +85 degrees C.

140 KMC

ULTRAMICROWAVE* EQUIPMENT BY



—it works

—it's accurate

—it's available

Complete data on request

DE MORNAY BONARDI

DE MORNAY–BONARDI
780 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

*TRADE MARK De Mornay-Bonardi for its millimeter wave equipment

See us at Booth 512, the WESCON Show

CIRCLE READER SERVICE CARD 3

Some useful applications for a delay lin of this type would be as a trimmer for long delay line (5 usec or more) to adju the tolerance of the line; as a variable puls generator with the taps controlling th width of the output pulse; to generate cloc pulses; or as a variable pulse formin network.

Delay Line CT-18 is 2½ inches long 1 inch wide and approximately 1½ inche high including threaded mounting studs o the underside of the case.

CIRCLE READER SERVICE CARD 11

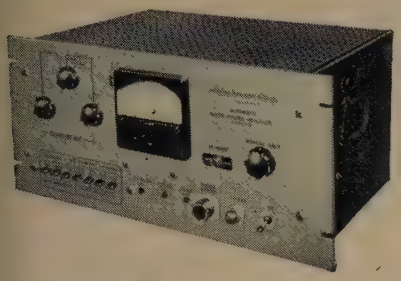
• • •

HIGH POWER C-BAND ISOLATOR BY RANTEC

The Model IC-400 C-band load isc lator, a product of the Rantec Corpora tion of Calabasa, California, covers th frequency band 4.6-6.0 KMC and provide 12 db minimum isolation (18 db in cente of band), with 1.0 db maximum insertio loss (0.6 db in center of band). Th Model IC-400 has been successfully teste at a power level of 300 KW peak, 30 watts average, in the presence of an ion izing source with a 2: 1 variable phas load impedance. The unit suffered n arcing or change in characteristics at thi power level. Constructed in UG 49/ waveguide; the isolator uses UG-149A/ flanges, is 4 inches long, and weigh 4¾ pounds.

CIRCLE READER SERVICE CARD 11

FOR AUTOMATIC NOISE FIGURE MEASUREMENT



Only THE NEW AIL TYPE 74 OFFERS THESE ADVANTAGES

- **Noise Figure Range, RF or IF**
  High Scale—23 to 36 db with extension to infinity
  Low Scale—0 to 25 db
- **Accuracy**
  Automatic:
  Low Scale—±1/2 db
  High Scale—±1 db
  Manual: ±0.1 db
- **Sensitivity**
  50 microvolts at 30 Mc;
  100 microvolts at 60 Mc
- **Bandwidth**
  6.0 Mc minimum

All these features at a new, low price **$765.00**

Ten AIL Type 70 Noise Generators provide continuous coverage from 12 Mc to 40,000 Mc . . . most complete line of noise generators available for automatic noise figure measurements.

Write for details

AIRBORNE INSTRUMENTS LABORATORY
1345 NEW YORK AVENUE
HUNTINGTON STATION, L. I., N. Y.
A DIVISION OF CUTLER-HAMMER, INC.

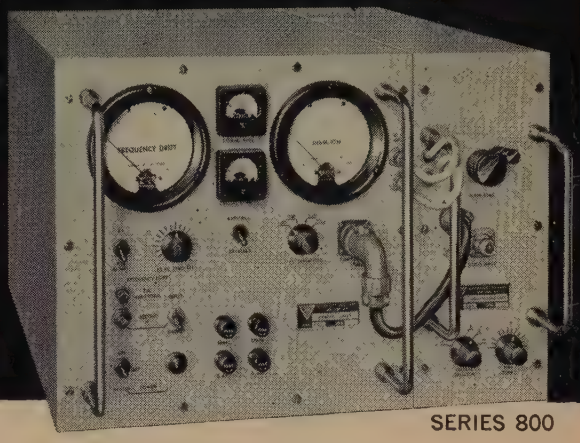
CIRCLE READER SERVICE CARD 31

From PITLOG — the leader and pioneer in stalos

STALO STABILITY TESTER

Accurate to 1 part in 10^9

A VERSATILE MICROWAVE STABILITY TESTER . . . DESIGNED FOR ANY APPLICATION REQUIRING PRECISE MEASUREMENT OF FREQUENCY STABILITY.



SERIES 800

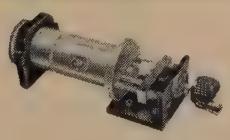
Measures long term drift and short term deviation in frequency bands from UHF to 10,000 mc. Checks stability of radar systems components such as stalos, cohos, klystrons and other stable signal sources — either on the production line or in the field. Particularly useful in the design, testing and maintenance of MTI equipped radars.

FEATURES:

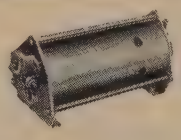
- Short Term Accuracy: 1 part in 10^9
- Long Term Accuracy: 1 part in 10^6
- Provision for Disturbance Frequency Spectrum Analysis
- Direct Meter Presentation of Frequency Drift and Deviation
- Full MIL Construction and Reliability

. . . and moderately priced!

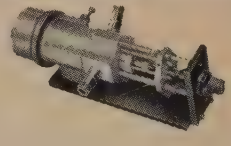
Other PITLOG components — **Tunable Stalos**
Self-contained stable local oscillators used as references for determining the phase or frequency shift of a radar echo. Offer high order of short term stability and high power output.



UHF Tunable Stalo
Frequency Range... 300-600 mc
Tuning Range.....10% +
Stability... less than 5 cps peak



L-Band Tunable Stalo
Frequency Range 1000-1500 mc
Tuning Range.....10% +
Stability.....4-8 cps peak



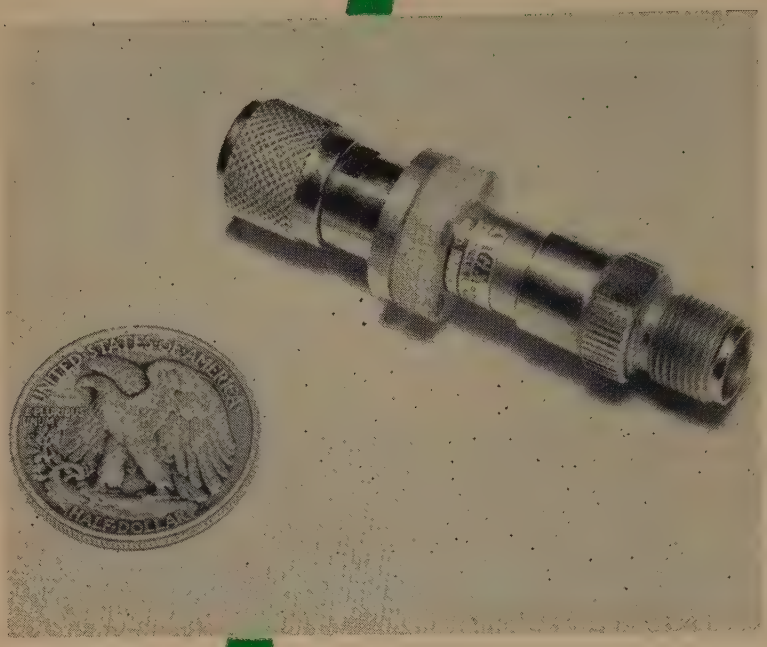
S-Band Tunable Stalo
Frequency Range 2000-3200 mc
Tuning Range..... 10% +
Stability.....7-10 cps peak

Write for Bulletin M-1

PITLOG

PITOMETER LOG CORP.
237 Lafayette Street New York 12, N. Y.
Advanced Instrumentation Since 1927

CIRCLE READER SERVICE CARD 37



SAGE

The SAGE 535 noise isolator is designed* with an integral crystal holder and DC return. Noise below 500 MC is suppressed, and it has a minimum of —45 dbm sensitivity from 1,000 MC to 8,000 MC. The SAGE 535 uses the IN21, IN23, or MA408 type crystal.

Price less crystal is $90.00 each in small quantities.

Delivery is from stock.

*Mostly Luck.

CIRCLE READER SERVICE CARD 32

SAGE laboratories, inc.
159 LINDEN STREET WELLESLEY 81, MASS.

Expanding the Frontiers of Space Technology in

RADAR and DATA LINK

■ Lockheed's work in the fields of radar and data link is concerned with research, design and development of systems and equipment for missile tracking, command guidance, detection and relay of information. Noise modulation techniques are under study as part of statistical communication theory and implementation of automatic space communication systems. A series of digital, command-control data link systems, utilizing solid state devices, have been developed, as have a number of radar beacon systems for missile tracking. Of significance, is the development of a radar firing error indicator that measures the intercept trajectory between target and attacking missile.

ENGINEERS AND SCIENTISTS

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown and challenging environments. If you are experienced in work relating to the above areas, you are invited to share in the future of a company with an outstanding record of achievement that spans nearly half a century, and make an important individual contribution of your own to your nation's progress in the race for space. Write: Research and Development Staff, Dept. H-27, 962 W. El Camino Real, Sunnyvale, California, U.S. citizenship required.

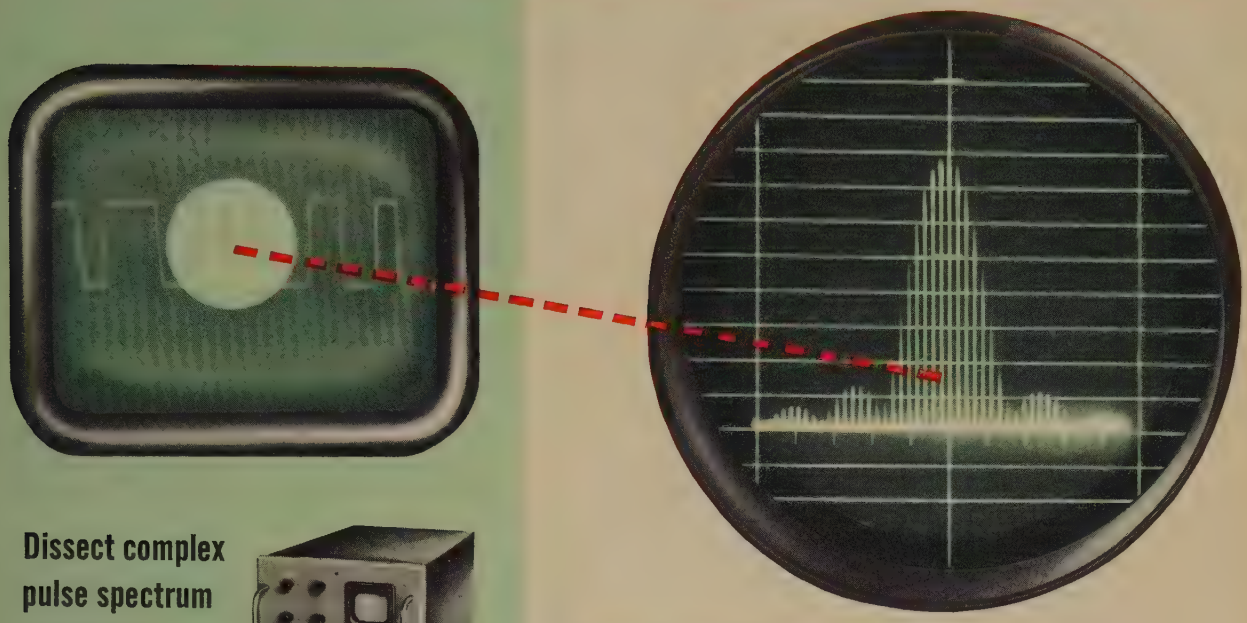
Lockheed
MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; Air Force Q-5 and X-7

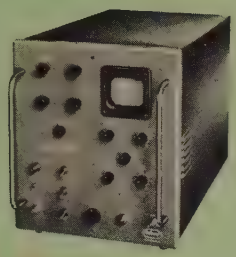
SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA
ALAMOGORDO, NEW MEXICO • HAWAII

VISUAL MICROWAVE ANALYSIS–10 to 44,000 mc

COMPLEX SPECTRUM DECODING



Dissect complex pulse spectrum visually by means of Polarad Model SD-1



MULTI-PULSE SPECTRUM SELECTOR

Used with any Polarad analyzer, this Model SD-1 Spectrum Selector permits complete analysis of any complex pulse modulated microwave signals. The unit decodes and isolates any segment of a complex pulse train and permits corresponding spectrum analysis of that segment.

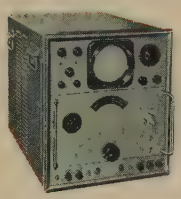
Model SD-1 Spectrum Selector displays pulse groups up to 180 microseconds duration (Model SD-1X: 350 microseconds).

Applications:

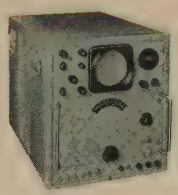
Design and operation of radar, telemetry equipment, IFF systems and beacons.

Analyze complex spectrum visually using any of Polarad's wide band

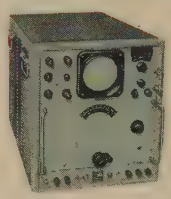
MICROWAVE ANALYZERS



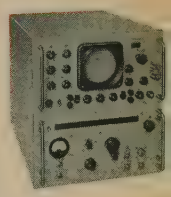
Model TSA Spectrum Analyzer — 25 kc resolution, 400 kc to 25 mc dispersion. 5 sensitive plug-in tuning units.



Model TSA-S Combination Synchroscope-Spectrum Analyzer — Displays pulse waveform or frequency spectrum. 5 kc to 5 mc adjustable bandwidth, 400 kc to 25 mc dispersion. 5 sensitive plug-in tuning units.



Model TSA-W Wide Dispersion Spectrum Analyzer — 100 kc to 70 mc dispersion. 7 kc and 50 kc resolution. Logarithmic amplitude display. 5 sensitive plug-in tuning units.



Model SA-84 Mu band Spectrum Analyzer — 10 to 40,880 mc in a single unit. 25 k resolution, 400 to 25 mc disper- sion. Simple bar switch, slide-rul dial. Military approved.

FREE LIFETIME SERVICE ON ALL POLARAD INSTRUMENTS

Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Handbook of Spectrum Analyzer Techniques" and "Notes on Microwave Measurements"

POLARAD ELECTRONICS CORPORATION
43-20 34th Street, Long Island City 1, N. Y.
Representatives in principal cities

MAIL THIS CARD

POLARAD ELECTRONICS CORPORATION:

Please send me information and specifications on:

POLARAD

- ☐ Model SD-1 Multi-Pulse Spectrum Selector
- ☐ Microwave Spectrum Analyzers
- ☐ Model B Microwave Code Generator (see reverse side of this page)

My application is:_____

Name_____

Title_____ Dept._____

Company_____

Address_____

City_____ Zone_____ State_____

COMPLETE FACILITIES— CODED MICROWAVE SIGNALS 950 to 10,750 mc

APPLICATIONS:

One integrated instrument:

Provides a complete system for simulating and testing missile and telemetry systems, IFF and radar, microwave beacons, direction finding and navigational equipment and microwave relay links.

Performs general purpose signal generator and oscilloscope measurements, multi-pulse testing and analysis.

SET FREQUENCY

Frequency range 950 to 10,750 mc is covered by four interchangeable microwave oscillator units, all stored in the instrument. Each has UNI-DIAL control, precision power monitor circuit to maintain 1 milliwatt power output reference level, and non-contacting short-type chokes to assure long life.

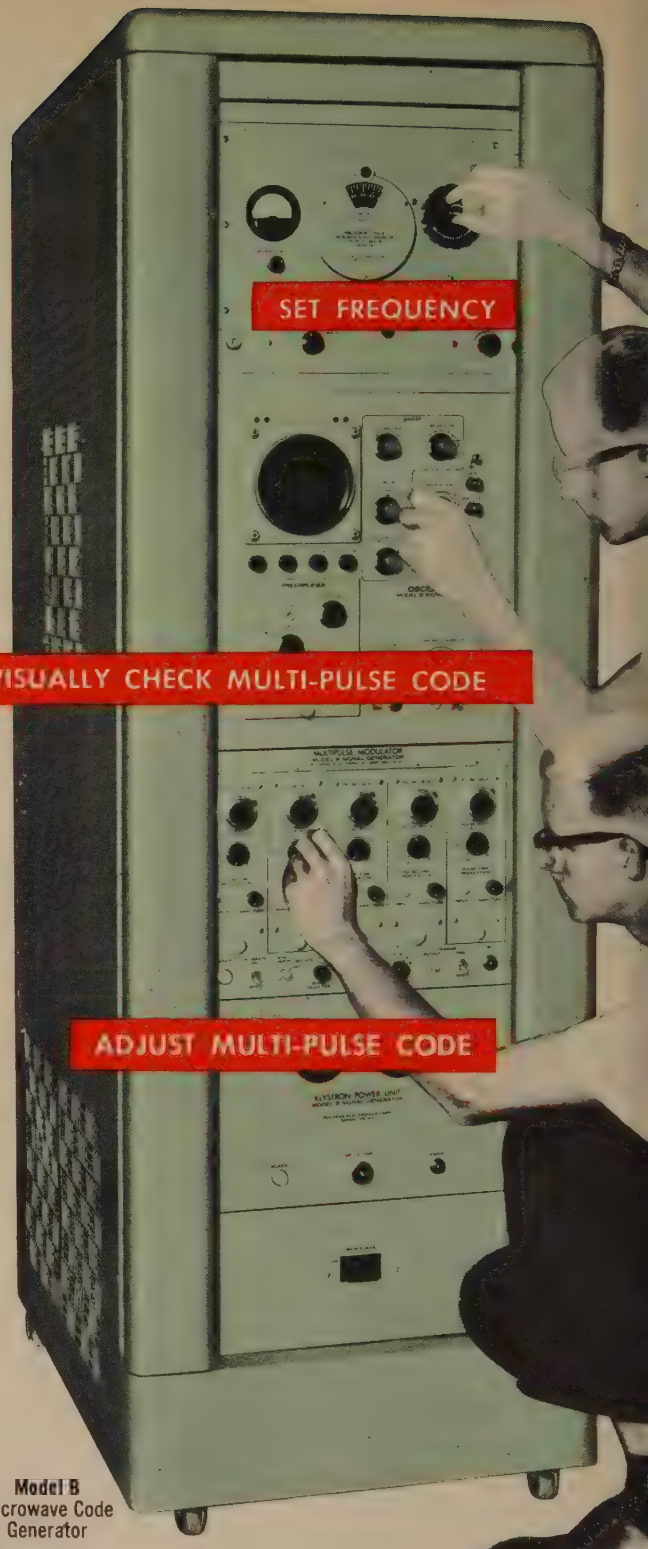
VISUALLY CHECK MULTI-PULSE CODE

Calibration of r-f pulse width, delay and group repetition rate is simplified by ability to view pulse train on a precision oscilloscope with a built-in wide band r-f detector.

ADJUST MULTI-PULSE CODE

Code modulation is achieved with five independently adjustable pulse channels providing: **pulse repetition rate** variable, 10-10,000 pps; **width** variable 0.2 to 2 microseconds; **delay** variable 0-300 microseconds. **Pulse rise and decay,** 0.1 microsecond.

NO ADJUSTMENT NECESSARY on self-contained power supplies. Klystron power unit adjusts to proper voltage automatically for each interchangeable tuning unit. Built-in AC regulator. Equipped with an electronically regulated low-voltage DC supply.



Model B
Microwave Code Generator

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MAIL THIS CARD
for detailed specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements"

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You are invited to a confidential exploratory discussion of your future with us. Contact Dr. Lawrence Gould for suitable arrangements.

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TECHNICAL PROGRAM

WESTERN ELECTRONIC SHOW AND CONVENTION

San Francisco, California • August 18-21, 1959

COW PALACE

	ROOM A	ROOM B	ROOM C	ROOM D	ROOM E
TUESDAY AUGUST 18 10:00 a.m.-12:30 p.m.	Session 1 Ultrasonics	Session 2 Reliability 1; Reliability Analysis	Session 3 Space Antenna Problems	Session 4 Computers 1	Session 5 Semiconductor Devices 1
TUESDAY AUGUST 18 2:00 p.m.-4:30 p.m.	Session 6 Audio	Session 7 Engineering Management	Session 8 Microwave Antennas	Session 9 Computers 2	Session 10 Semiconductor Devices 2
WEDNESDAY AUGUST 19 10:00 a.m.-12:30 p.m.	Session 11 Circuit Theory 1; Network Theory & Application	Session 12 Production Techniques	Session 13 Radio Wave Propagation	Session 14 Electron Tubes 1	Session 15 Semiconductor Devices 3
WEDNESDAY AUGUST 19 2:00 p.m.-4:30 p.m.	Session 16 Microcircuitry	Session 17 Circuit Theory 2; Active Networks	Session 18 Reliability 2; Reliability Engineering	Session 19 Vacuum Tubes 2	Session 20 Professional Group on Military Electronics 1
THURSDAY AUGUST 20 10:00 a.m.-12:30 p.m.	Session 22 Self Adaptive Systems	Session 23 Stereophonic Broadcasting	Session 24 Circuit Theory 3; Parametric Amplifier Circuit Theory	Session 25 Space Electronics & Telemetry	Session 26 Data Processing for Military Uses
THURSDAY AUGUST 20 2:00 p.m.-4:30 p.m.	Session 27 Information Theory	Session 28 Human Factors	Session 29 Circuit Theory 4; Transistor Analysis & Applications	Session 30 Automatic Control	Session 31 Microwave Theory and Techniques 1 — Microwave variable reactance amplifiers
FRIDAY AUGUST 21 10:00 a.m.-12:30 p.m.	Session 33 Component Parts	Session 34 Aeronautical and Navigational Electronics	Session 35 Instrumentation	Session 36 Automatic Control 2	Session 37 Microwave Theory and Techniques 2 — Microwave components & systems
FRIDAY AUGUST 21 2:00 p.m.-4:30 p.m.	Session 38 Nuclear	Session 39 Communication Systems	Session 40 Industrial Electronics	Session 41 Automatic Control 3	Session 42 Microwave Theory and Techniques 3 — Microwave magnetic resonance applications

EVENING SESSIONS — **Session 21** — Special Session, Wed., August 19, 8:00 p.m.-9:30 p.m., Gold Room, Mark Hopkins Hotel (to be announced).
Session 32 — Medical Electronics, Thurs., August 20, 8:00 p.m.-9:30 p.m., Mark Hopkins Hotel, Peacock Court.

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Antennas — up to 10,000 mc

Large Waveguide Components

Prompt Delivery of any type antenna or reflector — precision built to your specifications. Write for technical data.

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NEW! THE MERCURY "10" SERIES

TRIODE CAVITIES

10% tuning range

Fully standardized line for design and production . . . Frequency range from 225mc to top existing tube limits

DELIVERY—30 DAYS OR LESS!

Only JVM offers these outstanding engineering advancements—low cost standardized production—off-the-shelf availability—design flexibility and uniform performance.

Miniaturized MERCURY "10" cavities are precision engineered for restricted tuning range, minimum weight-frequency stability and temperature compensation. The "10" series includes 720 different cavities designed for maximum power and/or voltage ratings of a variety of tubes.

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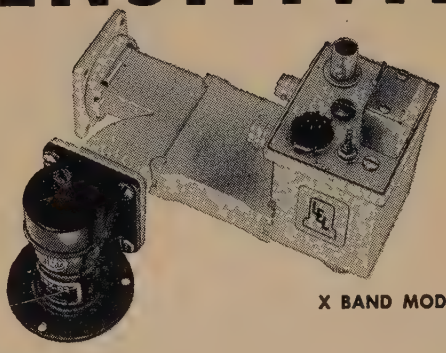
SENSITIVITY



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MATCHED

MIXER-PREAMPLIFIERS

A new series of matched mixer-preamplifier units, provides superior performance by designing the microwave and I.F. preamplifier as an integrated assembly. Each unit is designed for gain and selectivity, and is adusted for minimum noise figures. Standard units are available with output frequencies of 30 or 60 mc. Integrated mixer-amplifier assemblies are available for X, C, S, KA and KU bands, which include pre-selector and local oscillator if desired.

LEL 380 OAK STREET
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SYLVANIA ELECTRIC PRODUCTS Inc

A SUBSIDIARY OF
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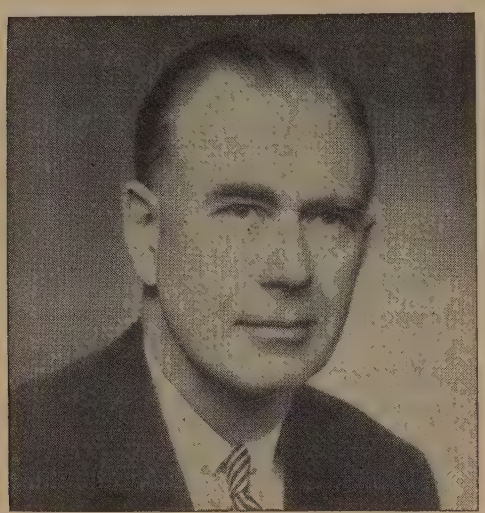


Robert E. Lewis, President, Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corporation.

BOX SCORE

NAME: Sylvania Electric Products Inc.
a subsidiary of
General Telephone & Electronics Corporation

LOCATION: Executive offices, 730 Third Avenue, New York 17, N.Y.
Plants, laboratories, sales offices and distribution centers throughout the United States.

PRODUCTS: See Sylvania Statistics Table.

HIGHLIGHTS: Sylvania, which was founded in 1901, is a highly diversified company. It is a leader in the fields of electronics, television-radio, lighting, photography, chemistry and metallurgy.
Microwave work includes all phases, from pure research through full production, both of components and systems.
In March 1959, Sylvania merged with General Telephone, largest independent (non-Bell) phone company, to form General Telephone and Electronics Corp. Although a wholly-owned subsidiary, Sylvania will retain its identity.

STATISTICS: 45 plants, with 2 under construction.
22 laboratories, with 1 under construction.
32 sales offices; 29 distribution centers.
5 wholly-owned subsidiaries.
1959 sales: approaching $400 millions.
27,000 employees.

DIVISIONS AND TYPICAL PRODUCTS

Sylvania Electronic Systems Military electronic syste and equipment, including electronic countermeasu and counter-counter measures; weapons systems, inclu ing missile and anti-missile systems; data processing s tems; computer components, radar and navigatio equipment; reconnaissance support systems; commerc and industrial electronic equipment.

Special Tube Operations Magnetrons, TWT's, BWC BWM's, (Carcinotrons), klystrons, ferrite devices, TF ATR's, "Rocket" planar triodes, decade counter tub trigger tubes, Pirani gauges; extensive microwave R &

Semiconductor Division Crystal diodes including r crowave diodes, transistors.

Sylvania Lighting Products Incandescent, fluoresce and mercury vapor lamps: Panelescent (electro-lumi escent) lamps; photoflash bulbs, fixtures, accessories, e

Receiving Tube Operation Receiving tubes; submin ture tubes; special tubes for computers, military and dustrial applications; ceramic stacked tubes.

Picture Tube Operation TV picture tubes; oscillosco tubes; industrial cathode ray tubes; military and rad cathode ray tubes.

Sylvania Home Electronics TV and radio receive high-fidelity phonographs, tape recorders.

Argus Cameras Cameras; motion picture and slide p jectors; photographic accessories.

Parts Division Tube sockets and bases; lamp hold and bases; custom molded plastics; metal stampings a deep-drawn parts; wire and ribbon; tools and dies.

Chemical and Metallurgical Division Tungsten a molybdenum powder, wire and parts; germanium a silicon; television phosphors.

Sylvania Research Laboratories Basic research in fie of electronics, physics, chemistry and metallurgy.

troduction

Previous articles in this series have largely focused on latively young companies devoted primarily or entirely some aspect of the microwave business. This month e turn to a company which is 58 years old and which involved in not one but several phases of microwave - and a vast complex of other industries, as well.

istory

The two predecessor companies of Sylvania — one unded in Massachusetts in 1901 and the other in Penn-lvania in 1906 — merged in 1931 to form the nucleus Sylvania as it is today. At the time of this merger, th companies primarily were producers of incandescent mps and radio receiving tubes. On March 5, 1959, lvania was merged into General Telephone Corpora-on, the country's second largest telephone system which ovides telephone service in parts of 30 states and anufactures a wide range of telephone equipment and vices. The name of the company at the time of the erger was changed to General Telephone & Elec-onics Corporation.

eeping in Touch

With plants spread literally from coast to coast, com-unication and coordination might seem to pose a oblem. It is the very electronics industry of which lvania is so much a part that has made possible the lution: virtually every plant, laboratory, office and arehouse is linked together by a unique 21,000 mile ivate communications and data processing network, in ldition to direct phone lines between many of the ants. Focal point of communications is the Data Pro-ssing Center at Camillus, New York, which houses a ant electronic computer. Among the functions han-ed by the system are the preparation and distribution payrolls, including the high speed printing of checks; stomer invoicing and record keeping; and preparation statistical operational reports. The system supplies e entire company organization with a wide variety of tal information in more detail, more accurately, and ore quickly than would be otherwise possible.

ube Maker Par Excellence

One of the firm's major fields of endeavor is tube-aking, in which it has over a quarter-century of ex-erience. Sylvania is one of the two largest manufac-rers of receiving tubes in the U.S. (having made over ½ billion!), and one of the two largest manufacturers f television picture tubes. Over the years of fighting s way up to this enviable position in the industry, lvania has made numerous significant technical con-ibutions including ceramic stacked receiving tubes, the 10° picture tube and, most recently, the "Framelok" rid, a revolutionary method of mounting grid wires hich prevents sagging.

utting Know-How to Use

What does all this have to do with microwave? lenty! From the time they started to produce "Rocket" lanar triodes for UHF applications at the end of World Var II, they began to draw on the pool of talent accu-ulated through years in the tube business. As the field of microwave began to grow and take on new significance, Sylvania gathered a nucleus of experts in research, in product development, in production, and in quality control. Many came from other divisions of the company; others came from leading colleges and universities, from MIT Radiation Lab and elsewhere. Though small in number at first, all brought a wealth of knowledge and experience. This group formed the basis of what has since grown into the company's Special Tube Operations.

STO — Microwave's Specialists

Special Tube Operations now utilizes the skills of almost 1,000 people, about half of whom are scientists, engineers and technicians whose efforts are devoted primarily to development and production of microwave devices, or pure microwave research. The Operation occupies over 100,000 square feet of space in two plants in Mountain View and Palo Alto, California, and one at Williamsport, Pennsylvania. Plans are underway to add another 30,000 square feet during 1959 to accommodate STO's expanding production requirements.

A perusal of the list of STO's employees reveals many familiar names in the microwave field who have made numerous contributions. Only a few can be mentioned here.

Meyer Leifer, Manager of STO, who has about twelve years experience in microwaves, is a Fellow of the IRE and a graduate of MIT's special training program for senior executives.

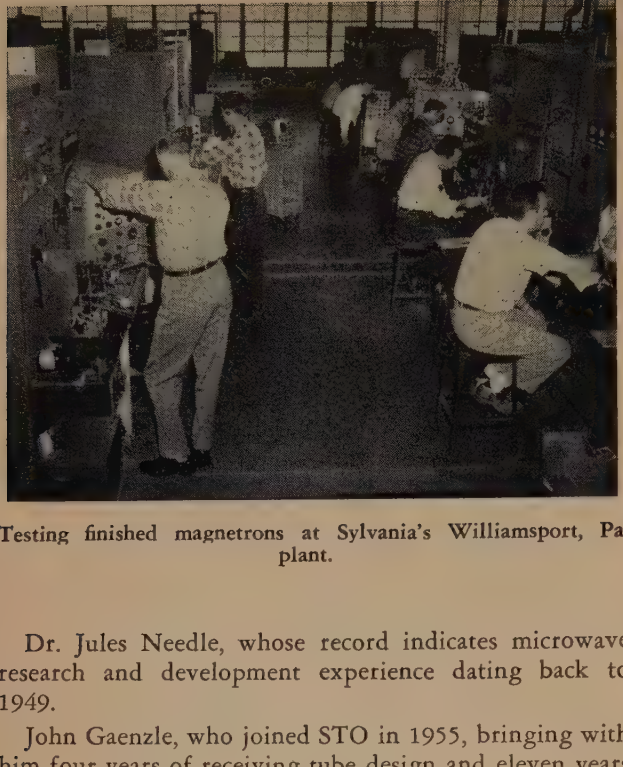
Dr. Rudolf Hutter, STO's Chief Engineer, a leading Sylvania engineer for close to two decades and the author of numerous patents and technical articles in the fields of microwave electronics and electron optics.

Dr. Daniel Goodman, Manager of STO's Research and Advanced Development, who has been responsible for traveling wave tube development since 1953.

Marshall Pease, known to microwave researchers primarily for his contributions in the area of crossed-field theories and as an Associate Editor of this journal.

Dr. Walter Kohl, holder of seven U.S. patents in the electronics field, who initiated work which led to the development of the electron microscope on this continent.

Traveling wave tube engineering area, Mountain View.



Testing finished magnetrons at Sylvania's Williamsport, Pa. plant.

Dr. Jules Needle, whose record indicates microwave research and development experience dating back to 1949.

John Gaenzle, who joined STO in 1955, bringing with him four years of receiving tube design and eleven years of Sylvania microwave tube development.

Dr. Romayne Whitmer, who carries the title of "Head of Theoretical Studies," and the author of publications in electron optics, gaseous electronics and network theory.

Dr. Robert Hill, specialist in plasma studies, who has spent the last six years with Sylvania on such subjects as electromagnetic wave propagation in a plasma, and microwave measurements of electron collision cross-sections in molecular gases.

Robert Palmer, who has been involved with tube design and development since 1937, including a period spent as Engineer-in-Charge of the Brimar Valve Works in England.

Gershon Wheeler, one of Sylvania's leading ferrite device engineers, author of publications in microwave components and circuitry, mathematics and network analysis, in addition to being an Associate of and frequent contributor to "the microwave journal."

Products for Progress

Special Tube Operations product lines cover a multitude of frequencies, powers and purposes, for applications from missile guidance to traffic control, and cloud mapping to electronic organs — a versatility equalled by few others in the industry. The microwave product lines include magnetrons, Carcinotrons, traveling wave tubes and backward wave oscillators, klystrons, TR and ATR tubes, waveguide windows, "Rocket" planar triodes (for UHF applications), and a variety of ferrite devices. Outside of the microwave area, STO manufactures decade counter tubes, cold cathode trigger thyratrons, and gas pressure measuring tubes.

The magnetron line, one of the fastest growing, has its major strength in X- and Ka-band types, at peak power levels up to 200 kw. Of major significance are the new X-band 7008 and 7111 which offer an 1100 megacycle tuning range, utilizing a simple and m reliable tuner mechanism than has previously b available.

Ferrite devices are developed and produced by Microwave Physics Laboratory, which is now a part Special Tube Operations. This closely-knit unit of entists and engineers, almost half of whom have Ph.D has developed a rare capability which enables it to m customer requirements at and beyond "state-of-the-a boundaries in addition to their applied research studi Available devices include waveguide and coaxial iso tors, and three and four-port "Tee" circulators at quencies from 1 to as high as 30 kmc, with up to 80 isolation. Although many of these devices are availa elsewhere, a comparison of the data indicates that S vania usually designs its units into surprisingly sm light packages. Ferrite limiters, switches, and e harmonic generators are also being produced with ch acteristics readily adapted to conform to the spec needs of the customer.

Specifications of the traveling wave tubes develop by Sylvania over the past few years show that the tub which include a number of permanent magnet focu types, are exceptionally rugged and possess outstandi electrical characteristics. Officials stated an intent to expand production sharply over the next few ye

An impressive line of microwave diodes is manuf tured by the Semiconductor Division in Woburn, Mas chusetts. Types in production include a large number premium diodes such as the 1N21E, 1N23E, 1N53B a 1N78B; and crystals using the Sylvania-developed polar construction. Recently announced was the velopment of a miniature microwave diode in a gl package (called "Micro-Min"), suitable for stripl and other applications where size is a factor.

Design for Tomorrow

Sylvania management has always placed considera emphasis on product development and Special Tu Operations management is emphatic about maintaini this policy. An indication of this may be seen in fact that the number of types of traveling wave tub magnetrons and ferrite devices have all more th doubled in the last two years. What's on the drawi board and test bench now for release in the near futu Company officials were reluctant to discuss details most items until electrical tests substantiate slider results, but they indicated among the achievements wh may be expected in the near future are improved te perature compensation of permanent-magnet focu TWT's, metal-ceramic TWT's, several ruggedized m netrons operating at higher power levels, a whole se of new ferrite devices and a number of klystrons.

Research for the Future

New scientific discoveries are being made today a rate which far surpasses anything in the past and e tronics is one of the fastest advancing of all the ences. Product development, though important, is sufficient by itself to keep a company in the forefr of the field. Recognizing this, Sylvania has built up virtually every operating division pools of talent, cilities and instruments devoted to pure research. Special Tube Operations, scientists are laying the grou

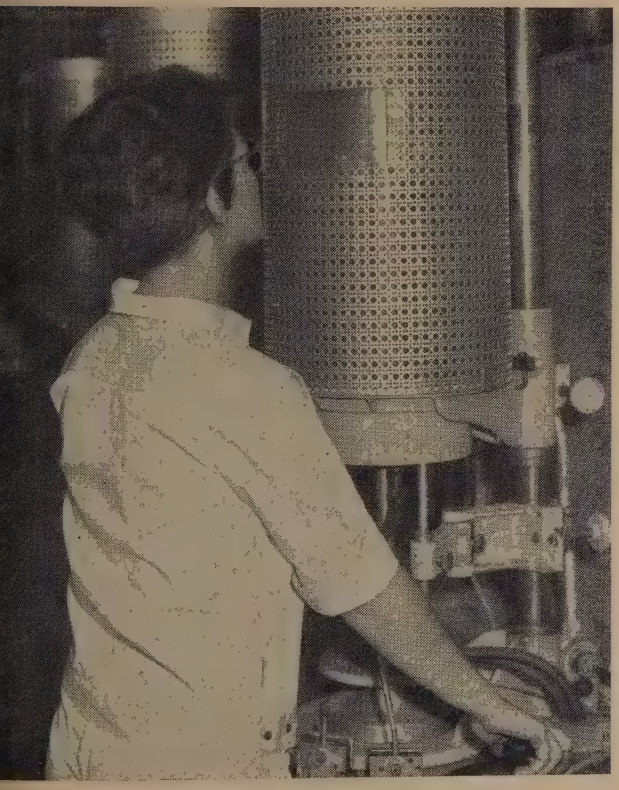
ork for microwave devices of the future by probing w theories in crossed-field tubes, type "O" interions and parametric amplifiers. Also under study is e feasibility of using ferriton for harmonic generation d an investigation into the attenuation of microwave gnals passing through the shock region which surunds supersonic vehicles.

Long range research in electronics, embracing physics, emistry and metallurgy is carried on at the Sylvania search Laboratories in Bayside, N.Y. Here, the oundwork is laid for the new principles and products the future. Sylvania's present strength in the microave field may be traced in large measure to the early ork at the Research Laboratories of many of the specialists already mentioned. Leifer, Hutter, Gaenzle, Whitmer, Palmer, all pioneered in the early research on avelling wave tubes and their application to modern icrowave systems. As this field emerged from the laboratory stage, these specialists formed the core of the ow flourishing Special Tube Operations.

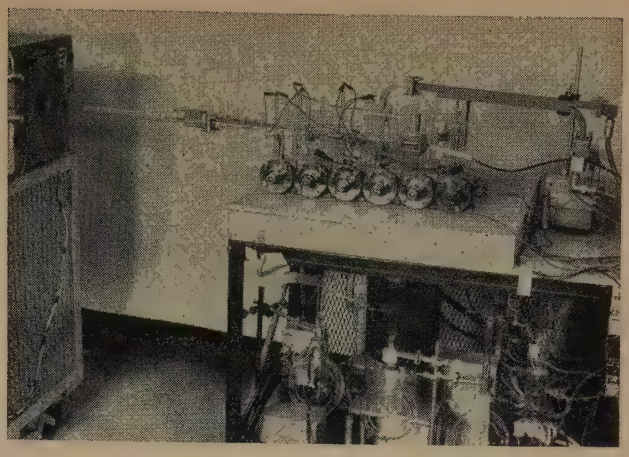
Today, the specialists of the future are working at the ontiers of the upper microwave frequency region with ew materials and concepts that will provide for the ntinued development of this vital field of electronics. Consultants from some of the country's leading universities are also used by STO, such as Dr. Hubert effner of Stanford, who is retained to assist with paraetric amplifier studies.

. . And Systems, Too

The systems concept of design, now in so much favor ith the military, is carried out on a grand scale by the ant Sylvania Electronic Systems, a division of the mpany which operates four plants, has two new ones nder construction, and has just completed a building



Bell jar brazing of klystron gun parts.



Plasma resonance investigations at Sylvania Mountain View plant; test bench set-up.

to house the executive and administrative offices. This one division alone has over 5,000 employees, including 1,000 engineers, and occupies almost a million square feet of working area.

Currently in the works are the B-58 ECM equipment; the F9C digital communications equipment; MOBIDIC, a mobile digital computer; UDOFT, a digital flight simulator; PLATO, an antimissile system; and other classified electronic and weapon system projects in the fields of electronic warfare; missiles; data handling; communications; and intelligence, navigation, and reconnaissance systems.

Even The Majors Merge

On November 6, 1958, Sylvania and the General Telephone Corporation announced their intention to merge, subject to the approval of stockholders. That approval was received on February 11, 1959. The following month all Sylvania stock was withdrawn and replaced by certificates bearing the name "General Telephone and Electronics," the new title of the surviving corporation.

General Telephone is the largest independent (non-Bell) telephone system in the U.S., operating one out of every 19 connected phones. The corporation also owns four telephone equipment manufacturing companies, various telephone directory companies, sales and service companies, and substantial interests in telephone operating companies in Canada, the Philippine Islands and the Dominican Republic.

Why should a large and successful company like Sylvania want to become a wholly-owned subsidiary of an even larger company? Among the important advantages to Sylvania are increased ability to finance further development, further diversification in products due to the research efforts of the two companies, availability of General's experience and background in foreign manufacturing and sales, the financial stability afforded by the telephone operations of General, and the ability to serve better the national defense effort.

Under the conditions of the merger, Sylvania functions as a separate corporate entity, retaining its name, identity, and operating procedure. In other words, the sign on the Sylvania corporate door says "Business As Usual — Only More So."

AT WESCON—

RAYTHEON MICROWAVE AND POWER TUBE DIVISION
WESCON BOOTHS 2131-2134

The Microwave and Power Tube Division of Raytheon Mfg. Co. will introduce their recently declassified QK-516 at Wescon. This is a high power pulsed tunable UHF magnetron suitable for airborne application.

Also shown by Raytheon will be the line of magnetrons, klystrons, traveling wave tubes, backward wave oscillators and amplitrons.

Attending Booths 2131-2134 for Raytheon will be R. Smith, R. Kimmel, B. Allgood, D. Yoder, and R. McCadam.

CIRCLE READER SERVICE CARD 116

• • •

BURROUGHS CORPORATION
BOOTHS 2919-2921

Burroughs Corporation has announced the availability of a new Ultra Long Life Jumbo Nixie® Indicator Tube Type B7031. The device is the fourth in a series of Long Life Nixie Tubes which are capable of continuous operation without failure for over 30,000 hours.

The new Jumbo Nixie Tube provides a numerical display of the digits zero through nine in a common viewing area. The characters are two inches high and are visible at distances of over 150 feet. In addition to its ultra long life, the B7031 features a side viewing design which makes possible close stacking of tubes. In this way, a large amount of information can be displayed in a minimum of space.

The new Jumbo Tube will be on display for the first time at the Wescon Show in San Francisco.

CIRCLE READER SERVICE CARD 117

• • •

SCIENTIFIC-ATLANTA
WESCON BOOTH 419

A new series of antenna pattern recorders is now available from Scientific-Atlanta, Inc., Atlanta, Georgia microwave instrumentation manufacturer. The new series, known as the APR-20, will be shown for the first time at WESCON in the Georgia electronics firm's exhibit, booth 419.

New features of Scientific-Atlanta's APR-20 series, which replaces the company's well known Model 121A Antenna Pattern Recorders, include the addition of a db meter for signal level monitoring, a built-in noise compression circuit for better signal to noise ratio, a lighted chart compartment, automatic single chart advance, writing speed of better than 40 inches per second and any or all combinations of log, linear, or square-root pen response obtainable with plug-in balance pots.

Three new plug-in modules are offered to increase flexibility and simplify service. One, a new high gain, low n
bolometer/crystal amplifier with bo
eter burnout protection. Two, a new
function amplifier. Three, a new
balance potentiometer.

CIRCLE READER SERVICE CARD

• • •

NATIONAL RADIO CO., INC.
WESCON BOOTHS 1707 - 1709

The addition of a line of edge-ligh
plastic panels for instruments has
announced by Stanley L. Rudnick,
eral sales manager, National Radio
Inc., a wholly owned subsidiary of
tional Company, Inc., manufacturer
electronic and electro-mechanical com
nents, and shortwave and amateur
ceivers. The production of edge-ligh
plastic panels by National Radio is
virtue of National's recent acquisitio
Mutual Electronics Industries Corp., fo
erly of Providence, R.I.

The new edge-lighted panels, manu
tured to meet QPL and to MIL-P-77
are made by an exclusive and prote
process to which National Radio Co.
the sole rights. The coating process,
other elements, make these panels scra
resistant and offer maximum visib
by day or night. Sizes, shapes and m
ings are made to specifications.

First industry-wide showing of
tional's edge-lighted panels will be
WESCON, National Radio's bo
1707, 9.

CIRCLE READER SERVICE CARD

TI Needs More John Maxwell's BS EE Louisiana Potytechnic Institute

MICROWAVE ENGINEERS

Men like John Maxwell are needed for high-level development and supervision — EE's who have 3 to 10 years experience in development, design and testing of microwave and high powered transmitter equipment prototypes. John has almost 9 years at TI, and now leads ASR transmitter and automatic performance monitor projects. Such experience can be used immediately. Your resume will get prompt attention by John R. Pinkston.

PROFESSIONAL PLACEMENT

APPARATUS DIVISION

TEXAS INSTRUMENTS
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DALLAS 9, TEXAS

LITERATURE . . .

MICROWAVE LITERATURE FRO
SYLVANIA

Two new catalog sheets summari
data on coaxial ferrite isolators and "T
ferrite circulators have been made a
able by Sylvania Electric Products In

Twenty-three types of coaxial fe
isolators are shown on one of the she
Available units cover an octave of b
width over the range 1 to 11 KMC.
units offer isolation between 10 and
db with 1 db of insertion loss. Any
them can be delivered with up to 80
isolation, according to Thomas D. Fu
marketing manager of Sylvania's Spe
Tube Operations.

"Tee" ferrite circulators as small
one-fourth the size of conventional
culators are described on the other sh
The miniaturization has been achieve
part by designing the units in a shun
configuration. One of the new units
scribed, the broadband FD-TC501, o
20 db isolation at 0.3 db insertion
from 5.925 to 6.425 kilomegacycles.

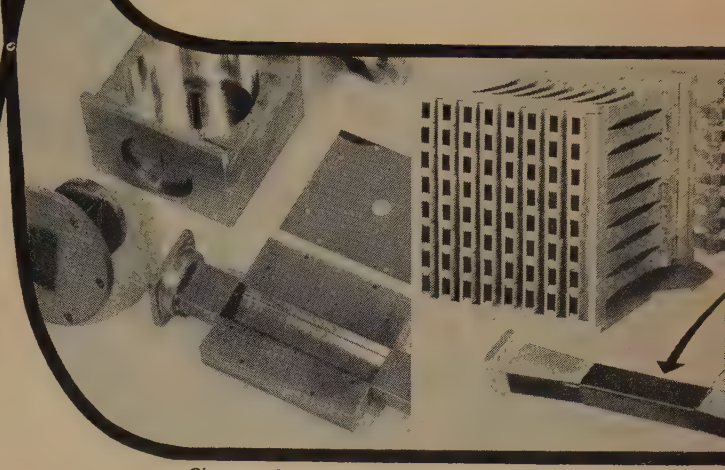
In addition to the catalog sheets
scribed above, a new magnetron cat
giving details on X-, Ka, and K-B
tubes has also been made available.

Included in the listing are four tun
X-Band tubes, two of which have
MC tuning ranges and minimum
powers of 200 KW.

CIRCLE READER SERVICE CARD

Opportunities at Hughes in

microwave research and development



Close-up of Hughes Ferrite Amplifier

X-Band Reciprocal Ferrite Phase-Shift Experimental Electronic Scanner

Modern electronic systems demand a broad range of technical competence. The Hughes Microwave Laboratory has unusually extensive capabilities in the antenna, microwave component, and radome fields. Its activities are co-ordinated in a balanced program of fundamental research, development, design and production engineering.

ANTENNA RESEARCH—Included in current studies are: electronic scanning, its information transfer functions, and its relationship to system performance; surface waves and conformal surface antennas potentially useful on nose cones or low silhouette applications; and the theoretical aspects of transmission through small radomes.

ELECTRONICS RESEARCH—These investigations are concerned with basic phenomena such as amplification, harmonic generation, limiting and switching with ferromagnetic and dielectric materials, and superconduction in thin films at microwave frequencies.

MATERIALS RESEARCH—In the field of Solid State Chemistry and Physics, studies are directed toward the synthesis and characterization of organic and inorganic compounds; new polymer systems; structural and electronic ceramics; and ferroelectric, ferrimagnetic and paramagnetic materials for electronic applications.

MICROWAVE ENGINEERING—the products of research are converted into advanced components, processes, and techniques for ultimate system application. Novel antennas, radomes, filters, and ferrite devices are being developed for the entire microwave and UHF spectra. New materials and processes are exploited for the production of ferrites and garnets, silicone plastics, ablative materials, high-temperature insulating and encapsulating materials, and electroluminescent panels. Research and engineering ideas are rapidly embodied in concrete forms through the facilities provided by a versatile design staff and a well-equipped shop.

Openings exist in each of the above areas. These positions offer excellent opportunities for qualified personnel in the fields of Physics, Chemistry and Engineering (Electrical—Microwave —Mechanical).

Please write: Mr. R. A. Martin, Supervisor, Scientific Employment
HUGHES RESEARCH AND DEVELOPMENT LABORATORIES
R and D Personnel Department, Culver City 48, California

the West's leader in advanced electronics

HUGHES

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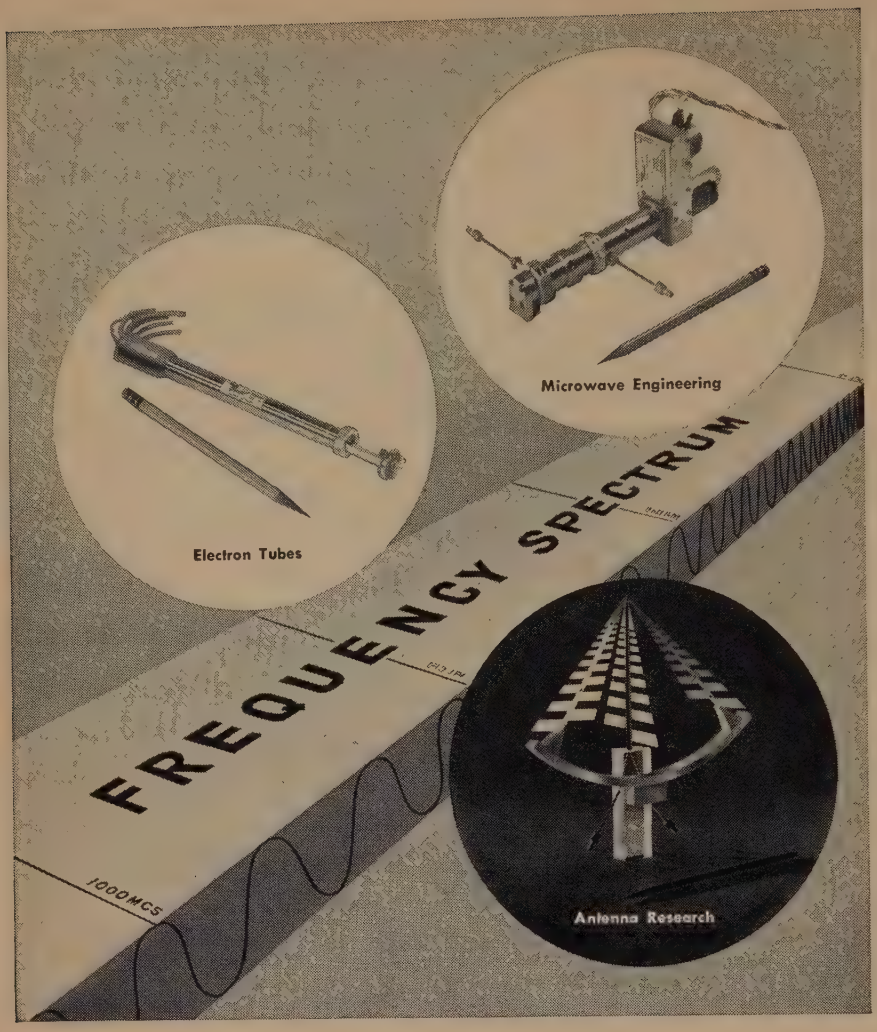

OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of the Bendix Aviation Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

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MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

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Research Laboratories Division
SOUTHFIELD, MICHIGAN

Bendix
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- MICROWAVE
- SERVOMECHANISMS
- I. F. AMPLIFIERS
- PACKAGING

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AVION acf

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involving these diversified fields of electronics:

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acf INDUSTRIES INCORPORATED
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COLFAX 1-4100

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MICROWAVE TUBE RESEARCH SECTION HEAD

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His ability and personality will play a key role in the continued success of this program. He must be capable of providing top technical leadership for this Section, plan, initiate, and supervise research programs, and assist in the selection of additional scientific personnel required.

He will work in a pleasant academic-like atmosphere, associate with very high calibre scientists, and will be free from many general administrative duties.

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NORELCO

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radar
microwave
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communications

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Expanding programs at PHILIPS LABORATORIES have created new opportunities for Physicists and Engineers who are capable of participating in interesting long-range experimental research programs.

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M.S. or Ph.D. in Physics or Electronics. A minimum of three years experience in Microwave Tube Research problems such as electrostatic focussing, electron beam studies, noise problems, and other phenomena associated with the various types of Microwave Tubes.

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In each of the aforementioned opportunities the individuals will associate with very high calibre scientists, work in a pleasant academic-like atmosphere, and will be free to publish and contribute their technical capabilities to an excellent research program. Salaries for these positions are open.

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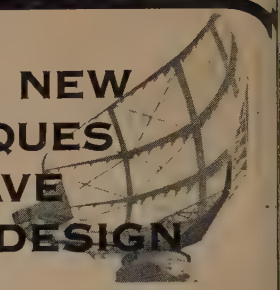

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A LOOK AT THE EXPORT MARKET

WILLIAM R. HEWLETT, Executive Vice President
HEWLETT - PACKARD COMPANY

WILLIAM R. HEWLETT, executive vice-president of Hewlett-Packard Company, was born in 1913 in Ann Arbor, Michigan. He attended Stanford University, graduating in 1934 with an A.B. degree. After a year of graduate work at Stanford, he enrolled at the Massachusetts Institute of Technology, where he received a Master of Science degree in 1936.

Returning to his home in Palo Alto, Mr. Hewlett was engaged for the next few years in electro-medical research. At the same time he pursued further graduate work at Stanford, receiving an E.E. degree in 1939. That year he and David Packard founded the Hewlett-Packard Company, an organization devoted to the development and production of electronic measuring instruments.

Mr. Hewlett has been instrumental in developing Hewlett-Packard from a two-man organization into the world's largest manufacturer of precision electronic measuring equipment. The company now produces over 350 different types of instruments, which are sold throughout the U.S. and in over 30 foreign countries. Hewlett-Packard employs some 2,000 people at its plants in Palo Alto and has a current annual sales volume exceeding $35 million.

Mr. Hewlett had a distinguished Army record during World War II, serving with the Technical Division of the Office of the Chief Signal Officer in Washington, D.C., and later heading the Electronics Section of the New Development Division of the War Department's Special Staff. He also was a member of the Compton Mission, which was sent to Japan immediately after surrender to form a quick appraisal of the Japanese scientific war effort. L s heavy work load at Hewlett-Packard's offices in Palo Alto, Mr. Hewlett is extremely active in industry and com- nity airs. He served on the Board of Directors of the Institute of Radio Engineers from 1949 to 1957 and was president of in 54. He is a fellow of both IRE and the AIEE, and is a director of several companies in the San Francisco Bay Area. His amu t activities include the chairmanship of the Board of Trustees of the new Palo Alto Stanford Hospital Center, and he is a stee of Mills College.

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n n years the electronics industry has become re y active in the development of overseas rk This activity includes not only the rapid ex- ns export sales operations, but the establishment fo manufacturing and distribution facilities as ll

Th nd of casting a marketing eye beyond our own de encouraging. It indicates that our young in- t y s g ining maturity and is willing to take positive l bold steps to meet increasing competition and to engthen America's stake in the free world economy. Compa ed to other U.S. industries, many of whom firmly entrenched in foreign markets, the electronics ustry is a Johnny-Come-Lately overseas. A primary son, of course, is our youth. Being a relatively new ustry, we have had to focus our attention on estab- ing our individual businesses and building domestic rkets for our products. Certainly most of us have l enough to keep us busy right here at home without cling the complex problems of overseas marketing. As our industry has gained strength and stature, how- r, it has provided increasing opportunities for sound, gressive companies to tap foreign markets. These portunities will continue to grow, particularly as the ustry develops new and better products to satisfy the ds of the free world.

Our own company offers a good example of the increasing importance of export sales to the total marketing picture. Although Hewlett-Packard has been manufacturing and selling electronic measuring instruments for twenty years, it has only been in the past five years that we have made a concerted effort to enter foreign markets. With the establishment of an Export Sales Department in 1954, we were able to achieve better coordination of our overseas selling activities and to develop a more ambitious marketing program. As a result, our export sales have grown substantially and now account for over 10% of our total volume. True, this is not a large percentage, but it does indicate that we are reorienting our management thinking to take advantage of export opportunities.

Two other recent developments underscore the company's mounting interest in foreign sales. One is the establishment of Hewlett-Packard S.A., a subsidiary company which is headquartered in Geneva, Switzerland, and which will coordinate sales activities in Western Europe. The other concerns our imminent plans for a manufacturing facility in the Stuttgart area of Western Germany. This plant is expected to be in production in late fall of this year. While it will be a modest operation, the company is hopeful that it will strengthen Hewlett-Packard's competitive position and will even-

tually grow into a major manufacturing facility.

These projects indicate that Hewlett-Packard, like many other electronic firms, is setting its overseas marketing sights on the prime target — Western Europe. This by no means implies that other areas of the free world are being excluded as potentially valuable markets. But it does mean that Western Europe, with its vast human and industrial resources, offers one of the most attractive possibilities for electronic manufacturers.

A recent development which has stimulated the interest of American businessmen in Western Europe is the creation of the European Common Market. One has only to spend a few days in Paris, Rome and other key cities to realize the tremendous significance of the common market. Outside of speculation on what the Kremlin will do next, it is the hottest topic of conversation in European business and financial circles.

The common market is basically an economic union of six countries of continental Europe — Belgium, France, Italy, Luxembourg, the Netherlands and Western Germany. It is designed, through a series of carefully-planned stages over the next 12 years, to encourage the free movement of goods, capital and labor throughout the member countries.

The formation of the common market is one of the most important economic steps ever undertaken in Europe and has enormous implications to American business and industry. A primary reason, of course, is that the common market area is one of rich industrial promise. The magnitude of its potential is clearly revealed in a few basic statistics about the area:

Population — The common market currently includes some 164 million people, a population nearly equal to that of the U.S.

Gross National Product — The GNP of the six common market countries is approximately $150 billion, or about one third of the U.S. figure. However, it is growing at a faster rate than the U.S.

Industrial Investment — The common market countries have more than doubled their annual investment in machinery and equipment since 1950. In 1957 their expenditures exceeded $16 billion, or fully 50% of the comparable U.S. figure.

Industrial Production — It has been expanding at an annual rate of almost 10% since 1949. The most industrialized member countries, Germany and Belgium, have not only broadened their industrial base but have also diversified their industrial production.

While the common market countries represent an area of unusual industrial growth, certainly the other nations of Western Europe should not be overlooked in evaluating growth potentials. Although they are outside the common market, these nations are included in what is known as the Free Trade Area. They, together with the common market countries, comprise an area with a population of nearly 250 million and a gross national product of over $215 billion. It is an area of dynamic growth, spurred by low labor costs and increasing industrial productivity.

Without attempting to analyze the varied and complex implications of the common market, it should be pointed out that this new federation will have a great competitive impact on U.S. manufacturers. Most observers feel that while the common market will adversely affect some American exports, its overall, long-range effects will be beneficial. Thus it behooves U.S. manufacturers, particul those of us in the electronics industry, to realistically praise the common market and to organize our efforts resources to meet its basic demands. Through careful timely planning, we can reap important benefits fr what may be Europe's greatest period of industrial grov

Major moves into the European market should not based on impulse. They require a thorough and system approach, with careful consideration of possible advanta and disadvantages. The decision of Hewlett-Packard set up a manufacturing plant in Germany, for exam was reached only after a painstaking study of such varia factors as labor productivity, proximity to key mark government attitudes toward American business en prises, and complex tax and fiscal considerations. Sim planning preceded the establishment of our subsidiary ganization in Geneva.

It should be pointed out that each company has its c unique requirements in selecting sites for foreign op tions. For example, Belgium's advantages may be far m important to Company A than to Company B. Each f must carefully evaluate the characteristics of various co tries and areas according to its specific production marketing needs.

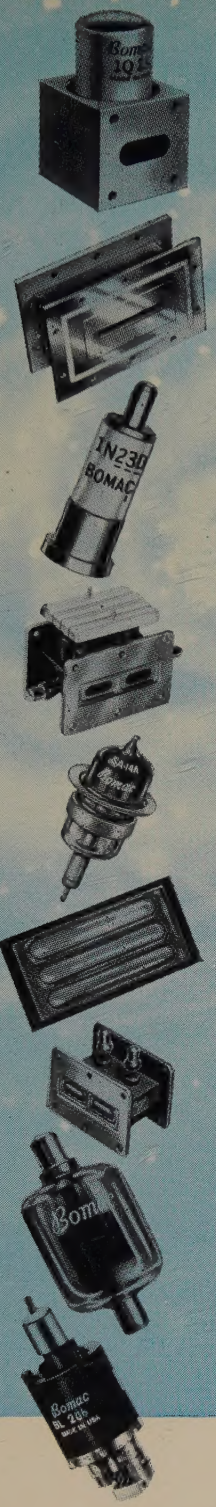
In considering a European marketing operation, it important to recognize certain basic differences in Am ican and European business practices. In America, example, we have a rather highly-developed communicat system between seller and buyer. This includes the reg and widespread dissemination of information on new pr ucts and services. In Europe, on the other hand, there greater need to go directly to the sales prospect and to d onstrate new products and their applications.

As a partial and rather interesting solution to this pr lem, Hewlett-Packard, S.A. has obtained a specially-desig bus which will contain the company's latest electr equipment. The bus, manned by highly-trained engin ing personnel, will travel throughout the Continent make periodic calls on sales prospects. In this way we h to bring our products directly to the customer and demonstrate those applications in which he is specific interested.

Another, and perhaps the most important considerat in establishing branch offices and plants overseas is creation of a friendly and receptive atmosphere am our foreign hosts. Unfortunately, there are a few m guided Americans whose attitudes and actions occasion incur ill will and who hinder, rather than promote, u tual understanding. Especially harmful is the attitude some businessmen who labor under the illusion that Am ica has exclusive rights on technical know-how. As any who is familiar with Europe's technological advan knows, nothing could be farther from the truth.

Industrial progress is based on contributions from m different people in many different lands. This is parti larly true in electronics. It explains, in large part, why m American firms are looking to their host countries to p vide the necessary skills and abilities for the success operation of overseas installations.

Honesty and integrity in business are as import abroad as they are at home. If the electronics industry apply these principles to its foreign operations, it can help but make a positive and lasting contribution to wo peace and understanding.



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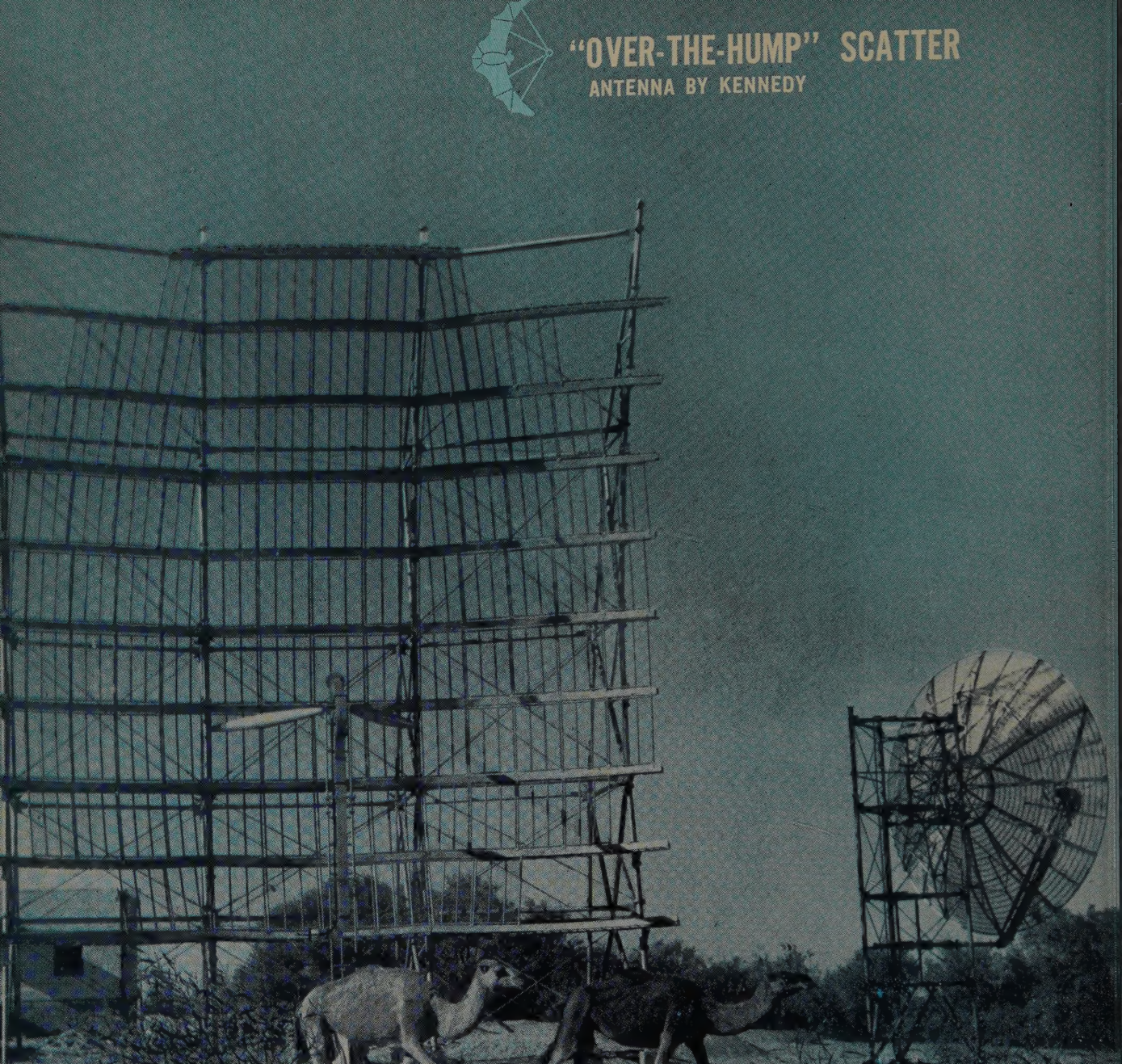

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